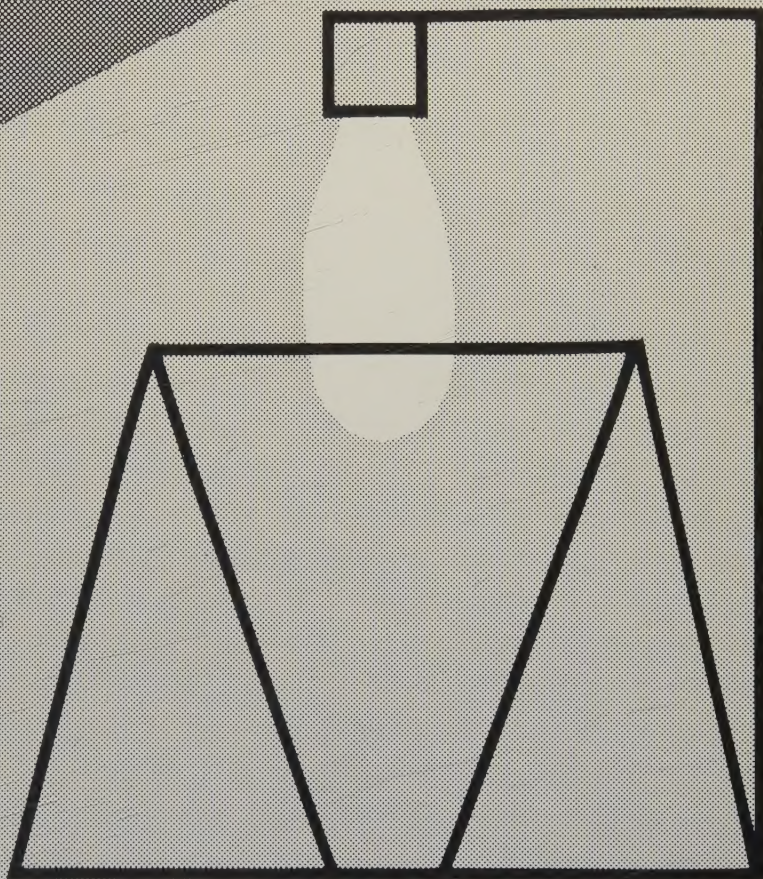
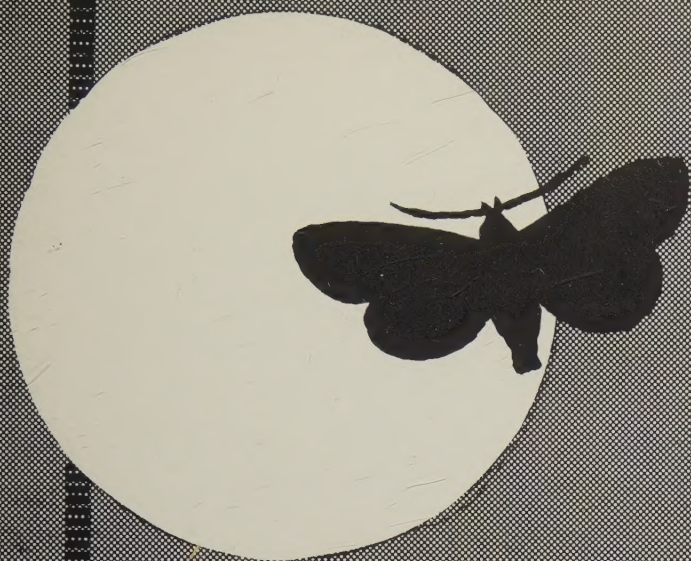


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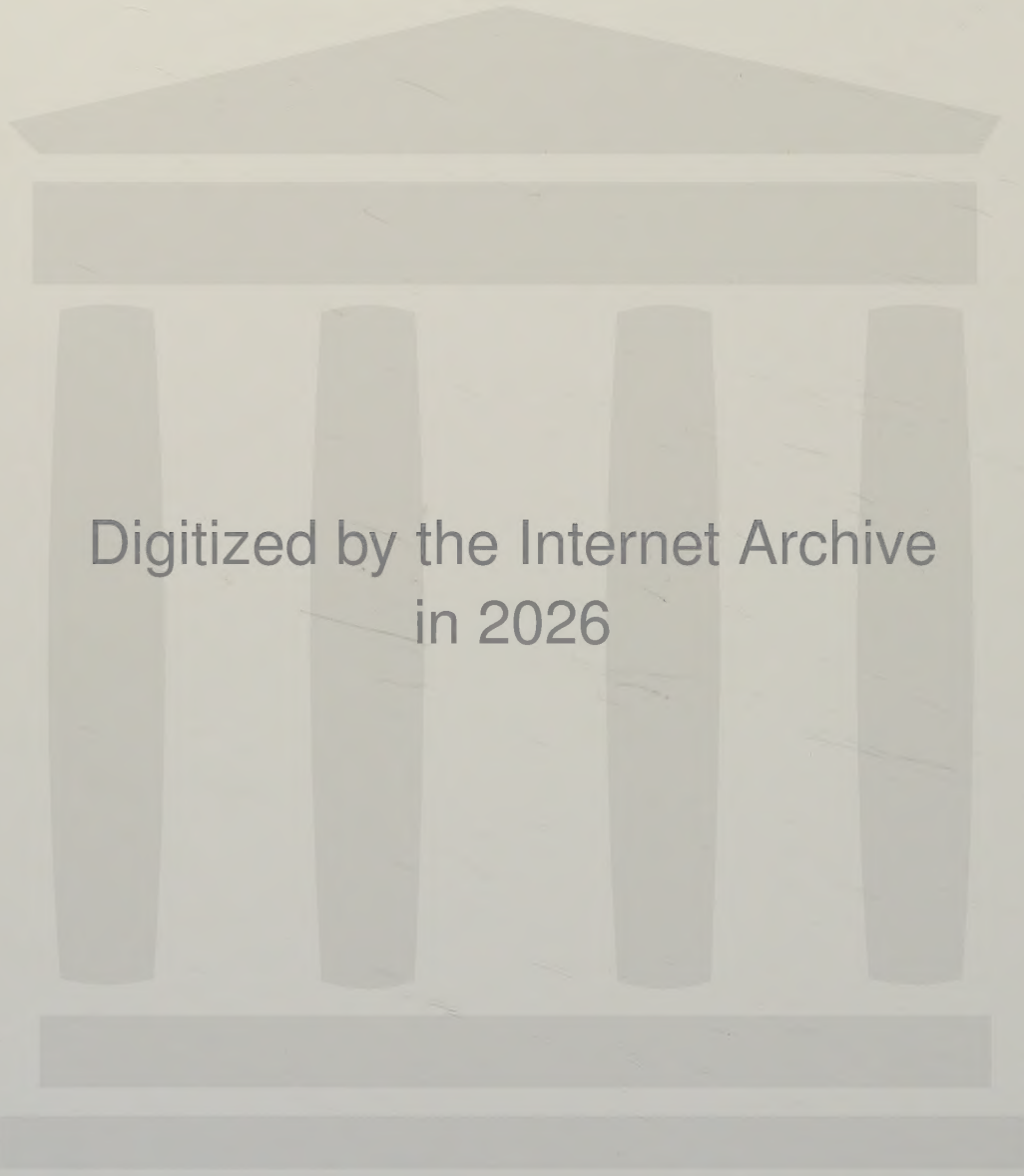
LEPIDOPTERA

*Flight activity of*  
**NOCTUIDS**

A STUDY BASED ON LIGHT TRAP EXPERIMENTS IN SOUTH SWEDEN

by BERT PERSSON





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# FLIGHT ACTIVITY OF NOCTUIDS ( LEPIDOPTERA )

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by

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BY

BERT PERSSON

ENTOMOLOGICAL  
INSTITUTION  
LEIDEN





## Contents

|                                                                                                       |    |
|-------------------------------------------------------------------------------------------------------|----|
| Abstract.....                                                                                         | 3  |
| Introduction.....                                                                                     | 5  |
| I. Field observations.                                                                                |    |
| A. The place for the investigations.....                                                              | 8  |
| B. Equipment and methods.....                                                                         | 8  |
| C. Registration of light trap catches.....                                                            | 12 |
| D. Flight activity in relation to weather factors<br>(Including a statistical treatment).....         | 14 |
| II. Laboratory observations.                                                                          |    |
| A. Observations on the influence of wind.....                                                         | 30 |
| B. Observations on the influence of light.....                                                        | 31 |
| C. Observations on the diel egg-laying activity.....                                                  | 39 |
| D. Observations on the influence of weather factors on the<br>longevity and hatching of noctuids..... | 40 |
| III. Discussion.                                                                                      |    |
| A. Flight activity and temperature.....                                                               | 46 |
| B. Flight activity and wind.....                                                                      | 49 |
| C. Flight activity and precipitation.....                                                             | 50 |
| D. Flight activity and light.....                                                                     | 51 |
| E. Influence of weather factors on the number of moths available<br>to catch.....                     | 54 |
| F. The co-operation of various environmental factors.....                                             | 55 |
| Acknowledgements.....                                                                                 | 57 |
| References.....                                                                                       | 58 |
| Appendix I: tables.                                                                                   |    |
| Appendix II: figures.                                                                                 |    |







## Abstract

1. In 1968 and 1969 noctuids were caught by means of a light trap at Bunkeflo, south of Malmö. The trap was constructed in such a way that hourly catches were separated. The temperature, the relative humidity, the air pressure, the precipitation, the wind velocity, and the wind direction were continuously registered at the catching place by means of meteorological equipment.
2. In 1968 25,463 noctuids were caught and in 1969 23,898 noctuids. The highest catch both years was obtained in July. Both years 23 per cent of the individuals caught were females. 182 species were found in the catch. Out of these, 10 species amounted to 60 per cent of the total catch of noctuids.
3. In 1969 and 1970 laboratory experiments and observations on the influence of weather factors and light on the flight activity of noctuids were performed, and also experiments and observations on the influence of weather factors on the survival of captured moths.
4. The influence of weather factors on the quantitative change in catch of noctuids from one night to the next was analysed by means of a standard electronic computer programme, BMD 02R, stepwise regression (Dixon, 1965). The influence on the change in catch of species was analysed by the same method.
5. It was found in the analysis of the catch and in the observations and experiments that quantitative changes in the catch of noctuids were not only due to changes in flight activity but also to changes in the number of noctuids available.
6. The night temperature was found to be the most important weather factor affecting the flight activity of noctuids. The influence is stronger when the temperature is low than when it is high.
7. The second most important weather factor governing the flight activity of noctuids seems to be the night wind velocity. It is probable that the influence of the night wind is stronger when the night temperature is low. High wind velocities have a strongly negative effect on the flight activity: above 5 - 6 m/s they normally have an inhibiting effect on the flight activity.
8. Precipitation also has an influence on the catch. This also applies to precipitation during the day before the catch. The amount of rain falling seems to be less important than the temperature conditions during the rain. Warm rains may even have a positive effect, while cold rains have a negative one. The influence of precipitation on the catch is partly an influence on the number of moths in the area and partly an influence on the flight activity (see point 9).







9. Day weather factors also have an influence on the catch of noctuids. This, however, mainly determines the number of moths flying in the area and only to a minor extent the flight activity. High day maximum temperatures and high day vapor pressure deficits cause desiccation of the moths. This effect is strengthened by high day wind velocities. During periods of high temperature and low precipitation, the number of moths available is reduced.
10. Light has a strong influence on the flight activity of noctuids. The diel distribution of activity is phase-set by the light. Light is the factor causing the moths to start their flight in the twilight period. The impulse to start caused by the light (or rather the decreasing light) is so strong that even hard weather conditions cannot suppress it. The response to light in the twilight period is temperature-dependent in such a way that the moths start at higher light intensities when the temperature is high.
11. Light also has a strong influence on the hourly nocturnal distribution of flight activity. In summer the night temperature seems only to have a modifying effect in this respect. Later in the year, however, the influence of the light decreases while the influence of the night temperature increases. In autumn the night temperature should be regarded as the most important factor governing the nocturnal distribution of flight activity.
12. In actograph experiments, where noctuids were exposed to moonlight, it was found that moonlight has a depressing effect on the flight activity. The response to moonlight and to the normal night light indicates that noctuids are sensitive to very small light intensities (hundredths of lux).
13. Due to the strong influence of light on the flight activity, cloudiness must also be regarded as an important factor affecting the flight activity of noctuids. This is particularly true regarding the flight activity in summer when the intensity of the night light is high, but also during full moon periods in other seasons.
14. The co-operation of various environmental factors is very complex. Different factors not only affect the flight activity directly, but also through other factors. A negative influence of one factor may be compensated by a positive influence of other factors. The factor in a certain night having the strongest influence on the flight activity is the factor nearest the minimum demand for activity (master factor). In summer this is normally light, and in autumn normally temperature, but it may also be wind or rainfall.
15. It seems that noctuids in our climate are hereditarily adapted to the long-time average weather situation during their normal flight period in the year.







16. The influence of weather factors on the catch of species is qualitatively the same as the influence on that of individuals. However, the influence seems to be quantitatively stronger on individuals than on the species as a whole.

17. The length of life of noctuids is temperature-dependent. Species flying in spring have a longer lifetime than those flying in summer. The shorter lifetime in summer, however, is probably compensated by an increased hatching of the pupae and the only result seems to be that the turnover of individuals in species flying in summer is faster. During very warm and dry periods, however, a decrease in the catch has been found.

## INTRODUCTION

A great deal of work concerning the flight activity of night flying insects has been carried out during the last forty years in different parts of the world. These studies, often based on the use of light traps, are usually intended to give quantitative and/or qualitative aspects on the flight activity of various insects.

In the present study some aspects of the flight activity of noctuids are discussed with special reference to the influence of weather factors and of the light. During the years 1968 and 1969, noctuids were captured at Bunkeflo south of Malmö (prov. Scania) by means of an automatic light trap with simultaneous registration of weather factors directly on the catching place. In 1969 and in 1970 laboratory experiments and observations on the influence of weather factors and light on the activity of captured moths were performed in the same place.

From the results obtained by other authors and results of preliminary tests, it could be expected that the relations between weather factors and flight activity are complicated and that advanced statistical methods are necessary in order to obtain even a rough picture of these relations. Modern light traps with mercury lamps give very high catches and thus form a sufficient base for statistical calculations. The primary material from Bunkeflo has been analysed by means of a standard electronic computer programme.

### Previous studies relevant to the present investigation

Light traps for catch of night-flying Lepidoptera have been used by a large number of workers.

Theobald (1926) obtained several species of fruit leaf tortricids in light trap experiments. Collin and Nixon (1930) studied the seasonal appearance of Spilonota ocellana. Hanna (1968) used a 160 watt mercury vapour bulb in a trap of the Robinson type for studies on the nocturnal distribution of activity of noctuids, among others Agrotis ypsilon. He investigated the influence





of temperature and humidity on the flight activity. He also observed the differences in the activity of males and females. Alma (1970) studied the influence of temperature and light on the flight activity of Operophtera brumata. He also made observations on the longevity of the male after capture. Harling (1968) also used a Robinson type mercury vapour lamp for studies on noctuids. He investigated the influence of temperature, humidity, rainfall and wind. Brown (1970) studied the influence of wind on the flight direction of night flying insects, including noctuids, by means of light trap catches in Kenya.

The most detailed investigations have been performed by the following four authors.

Williams (1935, 1936, 1939, 1940) made extensive experiments at the Rothamstead Experimental Station north of London. He used an automatic light trap for hourly catches and a 200 watt clear standard bulb as light source. He studied the influence of weather factors and moonlight on noctuids and also paid attention to sex differences. He also observed the number of species in the catch in relation to the number of individuals.

Bro Larsen (1943, 1949) investigated the influence of different weather factors on the flight activity of noctuids. She also studied the influence of light on the flight activity. She paid special attention to the minimum prerequisites for activity. She studied the migration of Plusia gamma and made a number of actograph experiments on captured noctuids.

Hosney (1953) investigated the influence of certain weather factors on the flight activity of noctuids and geometrids. He compared two localities, one in open country and one in a forest, and also investigated the influence of moonlight on the catch. He used advanced statistical methods for the analysis of the primary material.

Sylvén (1958) studied fruit leaf tortricids, noctuids etc., at Åkarp, Sweden, by means of light trap experiments. He used an automatic light trap and also paid attention to the diel distribution of flight activity. He investigated the influence of weather factors and moonlight on the flight activity and made a number of actograph experiments.

### Terminology

In the present paper the most important terms are explained as follows:

1. Activity. Identical with flight activity.
2. Artificial light. Light from electric bulbs.
3. Crepuscular activity. Flight activity during the twilight period.
4. Day. In this paper always the day before the flight. The time period between sunrise and sunset.
5. Day and night. The period between sunrise the day before the flight and sunrise the day after the flight.





6. Diel. The day in the sense of 24 hours.
7. Light. The normal night light.
8. Master factor. The factor having the strongest influence on activity.
9. Night. The period between sunset and sunrise.
10. Nocturnal activity. Flight activity at any time between sunset and sunrise.
11. Twilight period. Normally the civil twilight period.
12. Weather factors. Temperature, humidity, precipitation, wind and air pressure. A number of variants may be constructed (mean, maximum, minimum etc.).





## I. FIELD OBSERVATIONS

### A. The place for the investigations

The investigations were performed in a garden suburb named Bunkeflostrand situated immediately south of Malmö at lat.  $55^{\circ}30'$  N. and long.  $13^{\circ}00'$  E., 500 m. east of the shore of the Sound. The area covers about 25 hectares, and is surrounded in the north, east, and south by arable land, in the west by meadows (fig. 1). The height above sea level is about three metres. The ground is moraine clay overlying chalk. The area is covered by typical garden vegetation with fruit trees, lawns, flowers etc. Clusters of Spiraea, Syringa, Viburnum, Ribes, and Lonicera are common, and so are hedges of Crataegus and Thuja. Fruit trees dominate the higher vegetation and are common all over the area. They have not been marked on fig. 1. Among other trees, Betula alba is dominant and beeches, lime trees, poplars and sorb trees are also common, together with spruces and pines. The arboreal vegetation is planted. 35 years ago the whole area was arable land. The area is illuminated by ordinary street lamps except for the main street, Klagshamnsvägen, which has mercury lamps of the same type as in the trap, but weaker.

The trap was situated in a villa garden and the illuminated area was restricted by buildings, walls, fences, and fruit trees (figs. 2, 7).

### B. Equipment and methods

#### The light trap

Automatic light traps for hourly catches of moths have been used by Williams, 1940 and Sylvé, 1958 among others. Williams used a trap with eight jars on a revolving desk and Sylvé a similar arrangement. Both used clear standard bulbs as the light source.

In the present study a trap with a 400 watt mercury vapour bulb was used (Philips HPL, 400 W). Figs. 3 and 4 show the principle of the construction, figs. 5 and 6 a view of the trap. This was made of wood and had an aluminium lid. It was placed on a concrete foundation that had been dug down in such a way that the lid was at ground level (fig. 4). By means of an electric clockwork the current was switched on and off automatically. The catch funnel, consisting of two parts, was made of plexiglass, the exterior part covered with aluminium foil serving as light reflector. Inside the trap was a turntable with twelve partitions, each containing a glass jar. The turntable was driven by an iron weight. The jars were automatically changed once an hour in such a manner that they were successively exposed below the catch funnel. They contained 80 per cent alcohol and the moths were immediately killed.

The changes were controlled by an electric magnet connected to an electric clockwork. Every morning, the turntable had to be wound up again. The changes of the turntable were controlled from time to time. To each partition a test





tube was attached. These test tubes were successively exposed below a separate rainwater funnel on the lid, in such a way that the hourly rainfall could be measured. The trap was out of order on the following occasions:

1968. On July 16th: 2 hours, on August 30th: 4 hours, on September 3rd: 4 hours.  
1969. On July 29th: 2 hours, on October 12th: 8 hours.

It was only the hourly catch that was affected, because the bulb was lit as usual and the total nocturnal catch was registered.

The trap was very efficient compared to other traps, which can be seen from the following comparison.

Catch of noctuids:

1. Williams, Rothamstead, England, March - November 1935. 5460 moths (112 species) on a 200 W clear bulb.
2. Hosney, Rothamstead, England, March - November 1952. 17.954 moths (135 species) on a 125 W mercury lamp.
3. My own trap, Bunkeflo, Sweden, May - October 1969. 23.898 moths (162 species) on a 400 W mercury lamp.

Most of the moths flew directly into the trap on entering the illuminated area. Those alighting beside the trap normally took off again within a few minutes, and went into the trap.

#### Critical aspects

This report is based on the assumption that catches by means of a light trap will reflect the flight activity of noctuids present in the area. On the whole this assumption may be correct. However, some possible sources of error should be pointed out.

- (1) The flow of light from the bulb may fluctuate according to current variations. At Bunkeflo the current changes were small. The light flow from a transformer-governed mercury bulb has a high stability.
- (2) The power of attraction of the bulb may be influenced by surrounding artificial light sources, such as street lamps and light from buildings. The area covered by the light from the trap was very restricted horizontally by buildings, walls and high vegetation (figs. 2, 7). Hence the moths were not affected by the light until they were in the immediate neighbourhood of the catch area, and then disturbing light from other sources was weak compared to the strong light from the trap.
- (3) The flow of light from the trap is affected by the air conditions, notably during foggy nights. In summer, when the principal part of the catch took place, foggy weather did not occur. However, in autumn, when foggy weather occurred on some occasions, this factor may have been of some importance.
- (4) Moths may escape from the trap or alight in its neighbourhood without entering it. With very few exceptions (some cases observed in Plusia gamma),





no moths were capable of leaving the catch funnel. All insects who fell into the jars with alcohol were killed. Those who alighted beside the trap normally took off again within a few minutes, notably if other moths were entering the area.

(5) The changes of jars may take place too early or too late. This was of importance only to the hourly catch. The changes of jars never took place more than three minutes too early or too late. However, during nights with very high activity, up to ten moths might have fallen into the wrong jar.

(6) Some species may not be attracted to light. Among those who are attracted, there may be differences in the response to light. Several catches with bait traps have been performed in the area. The catches had almost the same composition as in the light trap with regard to species.

(7) There may also be differences between the two sexes in the response to light. Less females than males were caught by the trap. If this was due to differences in the response to light or to other reasons is not known.

#### Registration of weather factors

Sylvén 1958, among others, stated that it is important that the registration of weather factors takes place in the immediate neighbourhood of the light trap. At Bunkeflo the weather factors were registered directly on the catching place. The cages with the meteorological equipment stood only 8 metres and the rain gauge only 1.5 m. from the trap (figs. 2, 7). The temperature, the air pressure and the relative humidity were registered with a thermograph, a barograph and a hygrograph, respectively. The instruments were placed in a cage 1.5 m. above ground level. The thermograph was calibrated once a day by means of a thermometer, the barograph by a barometer and the hygrograph by a hygrometer and sometimes by a psychrometer. The thermograph worked with an accuracy of  $\pm 0.5^{\circ}\text{C}$ . The hygrograph worked correctly except that, when the relative humidity was 100 per cent, the hygrograph showed only 98 to 99 per cent. The barograph showed the same values as the barometer.

The wind velocity and the wind direction were registered on a rotating drum driven by a 24 hours synchronous motor (fig. 10). The anemometer gave impulses to an electric magnet (contact) and the impulses were transformed to strokes on a paper strip on the drum by a pen. The apparatus worked with an accuracy of 0.5 m/s, and was controlled from the time to time by a cup anemometer. The movements of the wind arrow were directly transformed to a round paper on the rotating drum. In this way the wind direction could be registered. The paper was then put into a simulator where the wind direction could be read (fig. 8).

The diel precipitation was measured by an ordinary rain gauge and the hourly rainfall during the night by an apparatus connected to the light trap (fig. 3).

The apparatus worked with good reliability. On two occasions, one in May





1968 and one in September 1969, the wind velocity registrator failed. The values for those two days have been taken from Bulltofta airport in Malmö.

#### The calculations of mean values on weather factors

In this paper the mean values on weather factors have been calculated from the hourly values obtained from the registration equipment. The mean values for the day (always the day before the catch) have been calculated from the hourly values between sunrise and sunset. The mean values for the night have been calculated from the hourly values between sunset and sunrise. As a consequence of this, in summer only six hours form the basis for the calculation of the mean values for the nights, against 14 hours in October (fig. 9). It should be observed that the mean values for the day and night together cannot be calculated from the mean values of the day and night respectively. The mean values for the day and night together have been calculated from the hourly values between sunrise the day before the flight and sunrise the morning after the flight.

The twilight period is also subject to variations from month to month. Beck (1968) gives the following values for the civil twilight period at Lat. 55°N. (Bunkeflo).

| Date          | Minutes | Date           | Minutes |
|---------------|---------|----------------|---------|
| Januari 1st.  | 45      | July 1st.      | 57      |
| February 1st. | 40      | August 1st.    | 47      |
| March 1st.    | 37      | September 1st. | 38      |
| April 1st.    | 38      | October 1st.   | 36      |
| May 1st.      | 43      | November 1st.  | 39      |
| June 1st.     | 55      | December 1st.  | 43      |

#### Registration of light

No registration of light was performed in connection with catch in 1968 and 1969. Not until 1970, when the necessary equipment was available, could registrations be performed. The night light was measured by means of a sensitive microphotometer (Evans Electroselenium Limited). A range selection switch on the photometer gave a choice of six ranges progressively increasing from range 1 by factors of approximately three. The full scale deflection (100 units) of the most sensitive range was attained with an illumination intensity of 0.043 lux. Thus it was possible to measure light intensities down to 0.005 lux. In order to prevent reflecting light from entering the photo cell head this was placed at the bottom of an interiorly black-painted wooden tube (100 x 27 x 25 cm). The tube was directed towards the spot in the sky where the light was to be measured (fig. 71). Connected to the microphotometer was a sensitive





electronic recorder (Metrohm Labograph E 478). In this way continuous curves could be obtained for the night light.

### C. Registration of light trap catches

#### Total catch

Altogether 83.004 moths were caught by the light trap (table 1). The total catch of night flying Lepidoptera was somewhat higher in 1969 than in 1968. The highest catch, of individuals as well of species (table 4, figs. 11, 14), for both years was obtained in July. The noctuids dominated the catch during all month except November 1969 (fig. 12). Almost 60 per cent of the catch for both years consisted of noctuids. In 1968, 25.463 noctuids were caught against 23.898 in 1969 (table 2). The daily catch of noctuids is presented in fig. 13. As can be seen from the figures, there are great differences in the magnitude of the catches on adjacent nights. These differences are due to changes in the environmental conditions and will be discussed later. In both years 23 per cent of the captured noctuids were females. (In the controlled hatch of adult noctuids (table 37) 52 per cent were females).

A total number of 182 species of noctuids occurred in the light trap during the two years (table 3). Of these, 38 species occurred in only one of the two years. A list of all species belonging to the family Noctuidae is given in table 38. It is obvious from the table that every species has a well defined flight period at almost the same time of the year in 1968 and 1969. This confirms the interpretation that the seasonal distribution of species is very stable, probably hereditary by natural selection and only to a slight degree modifiable by the prevailing weather conditions.

A small number of species is responsible for the main part of the catch (fig. 22, table 5). A comparison with Williams' results is given below.

| Williams, 1933-37<br>Rothamstead, England |                  | The author, 1968 - 69<br>Bunkeflo, Sweden |                  |
|-------------------------------------------|------------------|-------------------------------------------|------------------|
| species                                   | % of total catch | species                                   | % of total catch |
| 1. <i>Agrotis exclamationis</i>           | 23.4             | 1. <i>Agrotis exclamationis</i>           | 16.1             |
| 2. <i>Parastichtis monoglypha</i>         | 7.4              | 2. <i>Rhyacia c-nigrum</i>                | 9.9              |
| 3. <i>Palluperina testacea</i>            | 6.0              | 3. <i>Plusia gamma</i>                    | 9.7              |
| 4. <i>Rhyacia xanthographa</i>            | 5.8              | 4. <i>Rhyacia rubi</i>                    | 7.0              |
| 5. <i>Rhyacia c-nigrum</i>                | 5.7              | 5. <i>Elaphria morpheus</i>               | 4.6              |

In both cases A. exclamationis and R. c-nigrum belong to the five most common species.

The number of species in the catch is inversely correlated with the number of individuals. The decrease in the number of species nearly follows a straight





line when the species are arranged according to logarithmic size groups (fig. 15).

As can be seen from table 5 and fig. 22, there are great differences in the relative abundance of females in the catch between the twelve most abundant species. Completely deviating from all others is Sideridis pallens, with more than 70 per cent females in the catch. In both years, Plusia gamma had almost 39 per cent while Parastichtis monoglypha had only 8.6 per cent females. There is a slight tendency for species with a small number of individuals in the catch to have a higher relative number of females than species with a higher number of individuals (table 6).

Even if the total catch of noctuids in both years was almost the same, individual species showed great differences between the two yearly catches. P. gamma was more than three times more abundant in 1968 than in 1969 (table 22).

#### Phenological distribution

The highest catch for both years occurred in July but there are great differences between July 1968 and July 1969 as to the number of moths caught (table 2, fig. 16). In 1968, 36 per cent of all noctuids were caught in July, against almost 50 per cent in July 1969. This difference is probably due to the lower average temperature in July 1968 (fig. 16, table 8). On the other hand, the smaller number of individuals caught in July 1968 was compensated by the higher number caught in June and August.

On the whole, the distribution of catch on months follows a normal curve. This curve is also rather well correlated to the curve on the monthly mean night and day temperature if the catch is expressed in log. form (Williams, 1951). Also between the curve on the catch of individuals and the curve on that of species a good correlation is visible (figs. 14, 16) except that the higher number of specimens in July 1969 has no corresponding rise in the number of species caught.

The distribution of catch of males and females on months is shown in fig. 18, 19, 20 and table 3. In both years the highest catch of males occurred in July. In 1968, however, the catch of females was highest in August. This may be due to the low average temperature in July that year and to the high temperature in August. It should also be observed that the relative number of females in the monthly catches almost constantly increases from June to October, both in 1968 and in 1969 (fig. 21).

#### Diel distribution

Already in 1917, Ainslie noticed in the USA that more females were active before midnight than after. This was also found by Williams (1940). Bro Larsen (1943), in some of her observations, found a bimodal catch curve for noctuids





(both sexes together).

The result of the present study are presented in figs. 23, 24, 25 and table 7. The distribution is almost the same in 1969 as in 1968. The highest catch in both years occurred around midnight (fig. 23). The catches in June and July in both years are more concentrated around midnight than in August and September. In autumn the highest catches occur in the first part of the night and the catch curve is better correlated to the temperature curve (fig. 25).

Also regarding the distribution of catch of males and females there is a strong resemblance between the two years. However, between the two sexes evident differences exist. The males show their highest activity around midnight while the females are most frequently caught before midnight (fig. 24). During some summer months a bimodal catch curve was visible for the females; the second, weaker peak then occurred between 0100 and 0200 (fig. 25). As a result of this the relative number of females in the catch was higher in the early and late part of the night than around midnight.

The phenological and diel distribution of catch in relation to environmental factors will be discussed later.

#### D. Flight activity in relation to weather factors

Here the statistical analyses performed on the change in catch from one night to another will be presented in relation to the corresponding changes in registered weather factors. Also the influence of weather factors on the nocturnal distribution of catch and on the change in catch of species will be treated here. The registrations of weather factors and the calculations of mean values have been accounted for on pages 10 and 11.

A number of authors have noted the influence of weather factors on the flight activity of noctuids. However, as was pointed out by Sylvén (1958), many of the data are based on general impressions rather than on continuous observations. Four authors have made more thorough investigations on the subject; Williams, Bro Larsen, Hosney and Sylvén. Of these, Williams and Sylvén also paid attention to the nocturnal distribution of catch (see page 6).

#### 1. Change in catch from one night to another

##### The choice of weather factors for the analyses

Not only the situation during the night but also the weather conditions the day before the flight may affect the catch of noctuids. Consequently in the following analyses both have been considered. Hosney (1953) also took into account the weather factors of the day before the catch.

The number of factors that should be analysed is a delicate problem. On the one hand it is of interest to investigate the influence of certain factors



regarded as important, independently of other factors. However, during natural conditions no factor works independently. Thus, as Hosney (1953) pointed out, the calculation of a simple regression on a factor gives a false picture of its influence. At least those two or three factors regarded as most important should be analysed together. On the other hand, it is important to study the complicated co-operation between several factors and their joint influence on the catch. Such an analysis is difficult to perform and makes the influence of individual factors difficult to determinate. In the analyses presented in this report I have tried to cover both aspects by using only three factors regarded as important in the first analysis and eight factors in the second.

The following weather factors were registered: temperature, wind velocity, wind direction, relative humidity, precipitation, and air pressure. The factors registered can be expressed in several ways and a number of variants can be constructed. In order to obtain a preliminary picture of the complex interaction between different factors it was desirable to test all the factors registered, including a number of variants, as to their simple correlation to each other and to the catch. Besides this, it was thought to be worth while testing the quadratic values of some of the factors in order to see if their influence was linear or not. As the calculations were performed by means of a computer it was possible to test a great number of factor variants. Of these only a minor part were selected for further analysis.

The weather factors and their variants may be divided into four main groups: temperature, wind, humidity, and air pressure:

#### Temperature

mean night temperature  
 mean day temperature  
 mean day and night temperature  
 maximum night temperature  
 minimum night temperature  
 maximum day temperature  
 night temperature range  
 day temperature range  
 day and night temperature range  
 quadratic value of mean night temperature  
 quadratic value of mean day temperature  
 quadratic value of maximum day temperature  
 quadratic value of day temperature range





Wind

mean night wind velocity  
 mean day wind velocity  
 maximum night wind velocity  
 minimum night wind velocity  
 maximum day wind velocity  
 night wind velocity range  
 quadratic value of mean night wind velocity

Humidity

mean night relative humidity  
 mean day relative humidity  
 mean day vapor pressure deficit  
 maximum night relative humidity  
 minimum day relative humidity  
 day and night relative humidity range  
 quadratic value of mean night relative humidity  
 quadratic value of day mean vapor pressure deficit  
 night precipitation  
 day precipitation  
 night and day precipitation  
 quadratic value of day precipitation  
 quadratic value of night precipitation

Air pressure

mean day and night air pressure  
 change in air pressure from day before flight to day after  
 quadratic value of day and night air pressure  
 quadratic value of air pressure trend.

As a preliminary step before more extensive calculations and in order to obtain a picture of the correlation pattern, the simple correlations between different factors and between the factors and the catch have been calculated for each month. The correlation pattern for the month of June, July and August both years is presented in figs. 41 to 46. Only correlations significant at the 5 per cent level have been taken into account. As could be expected, factors belonging to the same factor group are frequently and normally positively correlated to each other. However, a number of significant correlations, both positive and negative, exist between different factor groups. It is also obvious from the figures that each month has its own very complex correlation pattern. Significant correlations between different factors and the catch are presented in table 9. A number of factors are correlated to the





catch. Note: 1. that the number of correlations is much higher in 1968 than in 1969; 2. that the factors belonging to the temperature group have the highest number of significant correlations to the catch, mainly positive; and 3. that the quadratic value of the mean night wind velocity is more frequently correlated to the catch than the value of the mean night wind itself.

When it comes to the selection of factors that should be used in the multiple and partial regression analyses, the selection has been based partly on the results obtained by other authors, partly on the results obtained by experiments on caged moth, and partly on the number of significant simple correlations between the factor in question and the catch.

As can be seen from table 9, the temperature factors show the highest number of significant correlations to the catch, mainly positive. Out of these factors the mean night temperature has been regarded as important by many authors. It also has 4 significant correlations to the catch. Consequently this factor should be selected for further analysis. The mean day and night temperature and the mean day temperature both show 5 significant correlations to the catch. As the former also includes the mean night temperature, already selected, the mean day temperature should be regarded as the most important. The maximum day temperature in experiments with caged moths has proved to have a definite influence on the death-rate of noctuids, especially when this temperature is high (fig. 90). Thus both the maximum day temperature and its quadratic value should be regarded as important and selected for further analysis. For the same reason the mean day vapor pressure deficit should be regarded as the most important of the humidity factors (fig. 90). The mean night wind velocity, like the mean night temperature, has been regarded as important by many authors. Its quadratic value shows 6 significant correlations to the catch and those both should be regarded as important.

The list of factors selected for further analysis will then be as follows: mean night temperature, mean day temperature, maximum day temperature, the quadratic value of the maximum day temperature, mean day vapor pressure deficit, mean night wind velocity and the quadratic value of the mean night wind velocity. How these selected factors are used in the calculations of partial and multiple regression is accounted for below.

#### The statistical treatment

The best method available at the moment for an analysis of this type of investigation is the calculation of multiple and partial regression, a method used by Hosney (1953). This method, although not perfect, has certain advantages.

(1). It allows the investigator to estimate the average change in log. catch caused by a unit change in a certain factor, the other factors regarded being



constant. However, the figures obtained are relevant only under the conditions prevailing in the situation analysed.

(2). It allows the investigator roughly to estimate the part of the variance in catch that can be explained by the relevant factors together.

Multiple regression is a very complex subject and hence the calculations are very lengthy when many factors are involved. The method is therefore well fitted to standard electronic computer programs. In the analysis accounted for here such a program has been used for the calculations, BMD 02R, stepwise regression (Dixon, 1965).

The best way of avoiding errors in the calculation is to calculate the difference in log. catch between two consecutive nights. In this study the calculations have been performed on the difference in catch between consecutive nights expressed in log. form  $(n + 1)$ , and on the corresponding differences in the weather factors involved in the analyses.

Each month of both years when catch took place has been analysed separately. The choice of a month as a suitable period is based on practical reasons, mainly in order to make possible comparisons with the results of Hosney and to allow a comparison between the corresponding month in both years. The picture of the influence of weather factors on the change in catch might have been clearer, however, if main weather situations such as high pressure periods and low pressure periods had formed the basis for the calculations. A month may include both types of weather situation with very different temperature, humidity, and wind conditions, which makes the analyses more complex.

Two analyses have been performed on each month; one with three factors involved and one with eight factors. The choice of factors for the analyses has been accounted for on page 17.

Analysis I. In this analysis the influence of the following three factors has been investigated: the mean night temperature, the maximum day temperature and, the mean night wind velocity. The factors are the same as those used by Hosney (1953). All the differences between the nights of the month have been put into the same calculation (diff. night 1 - 2, 2 - 3, 3 - 4 etc.). Note that each night has thus been represented twice and hence the differences are not independent of each other. However, the method has been used despite this source of error in order to allow comparisons with Hosney's results.

Analysis II. Here eight factors are involved in the calculations. The mean night temperature, the mean day temperature, the mean night wind velocity, the mean day vapor pressure deficit, the mean night wind velocity<sup>2</sup> and the maximum day temperature<sup>2</sup> are always included in the calculations. In addition, these include the two factors out of 32 possible with the strongest partial





correlation to the catch after 6 and 7 factors respectively have been taken into account. In table 11 to 16 are presented the calculations of the partial regressions on the six weather factors always tested. The "six factors calculation" in the tables is the eight factors calculation before the two last factors have been included on account of their partial correlation to the catch.

In order to avoid the source of error caused by the fact that the same night comes into the calculation twice, as in analysis I, in this analysis two different calculations have been performed on each month. The first includes the differences between the night 1-2, 3-4, 5-6 etc., and the second the differences between the nights 2-3, 4-5, 6-7 etc. Thus two values on the partial regression have been obtained for each factor. The average value of the two figures has then been calculated and gives the value for the factor in the actual month. The same method has been applied to the values of standard errors and of multiple regression. As a result of the use of two different calculations for each month, the factors selected with regard to the strongest partial correlation to the catch may vary from the first calculation of the second. Note also that new factors put into the calculation affect the size of the partial regressions on those factors already being taken into account. For example the partial regression on the mean night temperature is not the same in analysis II as in analysis I (table 11).

The variance that can be explained by the weather factors tested has also been calculated (from the multiple regression). The figures obtained in the 8 factors calculation after six factors have been introduced should be regarded as the most reliable. The figures obtained in the 3 factors analyses and in the 8 factors analyses after eight factors have been introduced are less reliable, due to the errors involved in the calculations (see above).

### Results of the analyses

#### (1). Mean night temperature, (fig. 26, table 11).

The highest number of significant regressions were found on this factor (table 10). Out of these regressions only one, in June 1968, was negative. More significant regressions were found in 1968 than in 1969. The regressions were also on the average stronger in 1968 than in 1969. The strongest regressions were found in months with low average temperatures (May 1968, July 1968, August 1968). July 1968, the only month with an average temperature below the normal, shows the strongest regressions of all months tested. Observe that the strong regressions found in September of both years in the 3 factors calculation proved to be insignificant in the 8 factors calculation.

#### (2). Mean day temperature (fig. 27, table 12).

Positive and negative regressions were found both in months with high temperatures and in months with low temperatures. However, in the warmest months





of both years, August 1968 and July 1969, the regressions on the mean day temperatures were significantly negative. The strongest negative regression was found in September 1968, a month with a very high average temperature.

(3). Maximum day temperature (fig. 28, table 13a, 13b).

No significant regressions were found on the maximum day temperature itself. On high maximum day temperatures, however, four significant regressions were found, all of them negative.

(4). Mean day vapor pressure deficit (fig. 29, table 14).

Only two significant regressions were noted, one positive in October 1968 and one negative in June 1969. In October 1968 the monthly precipitation was more than double the normal, while June 1969 was the driest month of all those observed.

(5). Mean night wind velocity (fig. 30, table 15).

On this factor many significantly negative regressions were found in the 3 factors analysis, both in 1968 and 1969. The regressions were on the average stronger in 1968 than in 1969. Observe that in the 3 factors analyses only one regression was insignificant, in July 1969, and this despite the fact that the average wind velocity was as high as 2.3 m/s. July 1969 was the warmest month of all those investigated. In the 8 factor analysis only two significant regressions were noted. This may be due to the fact that in this analysis high mean night wind velocities were analysed separately (table 16, fig. 31). On high mean night wind velocities 5 significant regressions, all of them negative, were noted.

Explained variance (six factors analysis)

As can be seen from fig. 33 and table 17, the variance that can be explained by six weather factors was higher in 1968 than in 1969. In 1968, 75 per cent of the variance in catch could be explained by the six factors tested against 65 per cent in 1969. The difference between the two years, however, is not significant. The figures obtained were on the average higher than the figures presented by Hosney 1953. This is probably because more factors were tested at Bunkeflo. In 4 month out of 5 the explained variance was higher in 1968 than in 1969. A study of fig. 33 shows that in all these month the mean day and night temperature was lower in 1968 than in 1969. The greatest difference between the two years was found in July, the month which also showed the greatest difference in mean night and day temperature between the two years. July 1968, having the lowest average day and night temperature of all the months tested, also showed the highest significant explained variance of all months (94 per cent). In June both years, when the temperature was comparatively high, the explained variance was very low and also insignificant. The same was the case



with July 1969.

#### Weather factors not taken into account in the previous analyses

Factors not at all considered in the analyses above, such as wind direction, thunder, and fog, and such as are not obligatory in the calculations and only occasionally noted in the results of the analyses, such as precipitation and air pressure, are treated here.

#### Precipitation and catch

The influence of precipitation has been tested by the method used by Hosney (1953) on the influence of moonlight, foggy weather and the duration of rainfall. Thus catches on nights with rain during the night or/and the day before the night have been corrected for weather factors analysed in the 3 factors analyses (mean night temperature, maximum day temperature, and mean night wind velocity). The corrected catch has then been compared with the real catch and the difference has been calculated. The method used is very rough and not at all perfect. Thus is quite possible that the divergences noted are due in great part to factors other than precipitation. The light conditions are quite different during rainy nights compared with clear nights, especially around mid-summer. If the three factors for which corrections are made diverge greatly from their average monthly values, the corrected figure obtained is very unreliable. For example: on June 17th, 1968, the maximum day temperature was as high as  $29^{\circ}\text{C}$ . while the average maximum for the same month was only  $20.7^{\circ}\text{C}$ . The insignificant partial regression on the maximum day temperature in the 3 factors calculation was  $+0.03296$ . This gives a positive correction on this factor of  $0.2536$  for June 17th. However it has been shown (fig. 90) that high maximum day temperatures have a clearly negative effect. Consequently the real correction should not have been positive but negative. In the 8 factors calculation the regression on high maximum day temperatures was also significantly negative ( $-0.01332$ ). In other words, when the maximum day temperatures are very high, the figures obtained for the deviation from the corrected catch are often negative when in reality they should have been positive.

The corrected figures on the log. catch during days or (and) nights with precipitation have been compared with the real log. catch and the deviation has been calculated (table 19). This deviation has been regarded here as caused by the rainfall (see, however, the reservations above as to light). As is evident from table 19, precipitation may have both positive and negative influence on the catch. In 1968, rainfall on an average had a small negative influence. The negative figures obtained in 1969 are due to three nights in July and in reality should have been positive (see below). The precipitation in 1968 (only the month of June, July and August both years have





been taken into account) was also much higher than in the corresponding months in 1969.

### Results

In June 1968, when the temperature was above normal, rainfall night and day and rainfall during the day both seem to have been positive. Also rainfall in the night (only one occasion, the example referred to above) was positive (see B, in table 19) even if the figure presented in the table is slightly negative. In July 1968, a very cold month with a precipitation more than double the normal, rainfall seems to have had strongly negative effect, especially during the day. In August 1968, day and night rain occurred on only one occasion, when the temperature was very low. The effect also was strongly negative. Day rain on the other hand seems to have had a slightly positive effect. In 1969, June was a very warm and dry month. Only 30 mm rain fell. Rainfall then seemed to have had a strongly positive effect, especially rainfall during the day. In July 1969, the figures obtained for day and night rain and for night rain are negative. The three actual occasions, however, include June 7th when the wind was very strong (see C, in table 19) and also June 24th and 31st when the maximum day temperature for which correction was made was very high (see above and also B, in table 19). Consequently the rainfall in July, instead of having a negative effect, seemed to have a positive effect.

In August 1969, day and night rain and day rain had a negative effect while night rain showed a positive effect. The day temperature during rain was also below normal, while night rains occurred in connection with temperatures above normal. In the analysis presented earlier the regression on ample rainfall during the night, in August 1969, was also close to positive significance.

If the two figures for July 1969 discussed above are regarded as positive, on 8 occasions out of 10 when rainfall occurred in connection with temperatures above normal, then rainfall had a positive effect. On 6 occasions out of 8 when rainfall occurred in connection with temperatures below normal, the effect was negative. A calculation shows that  $x_{(1)}^2$  of the difference as to the effect of cold and warm rains is 5.44 :  $P = 0.02 - 0.01$  (see also fig. 35). The amount of rain seems to be of little importance. Fig. 34 shows that even small amounts of rain show both strongly positive and strongly negative deviations from the corrected catch. Also heavy rains may have a positive effect. In table 19 C, rainy nights with strong wind velocities are presented. Usually very great deviations from the corrected catch are noted. The deviation on July 7th is the strongest registered.

On two occasions rainfall was included in the analysis on account of its partial correlation to the catch. Except for August 1969 (see above), a significantly positive regression was noted on high nocturnal precipitation





in September 1969, the month of all those observed with the smallest precipitation, only 18 against normally 50 mm.

#### Air pressure and catch

Fig. 36 shows that the catch in connection with low air pressure was lower than when this was moderate or high. The catches at moderate air pressures were also slightly higher than those at high air pressures. The highest air pressures were correlated with high temperatures and weak winds. Despite this, the catches were largest when the air pressure was moderately high.

#### Wind direction and catch

The wind directions in 1968 and 1969 are presented in figs. 37 and 38. The pattern was not the same in 1969 as in 1968. In both years, winds entered the area from all directions but those from the northwest were rather uncommon. In 1968 winds from the southwest (WSW, SW, SSW) dominated, while in 1969 winds from the southeast were predominant. However, these two directions were well represented in both years and so were winds from the north. In 1969 winds from the northeast were more common than in 1968. In 1968 winds from the southwest and south coincided with the lowest air pressures, in 1969 winds from the west. East winds coincided with the highest air pressures in both years. This is also normal in the area, with winds from the southwest and west bringing low pressures, winds from the east high pressures. In 1968 wind from the southwest were on an average stronger than winds from other directions. In 1969 the west winds were very strong (average 4 m/s).

The distribution of catch on different wind directions is hard to understand. Both high and low catches have been obtained with winds from all directions. There is, however, a tendency for winds carrying low pressures to give smaller catches. These are also usually stronger than others. In 1968 they also gave a very high precipitation, mainly as showers, while the heavy rainfall in winds from the southeast the same year was connected with thunderstorms. In 1969, strong winds from the west carrying low pressures gave very small catches.

A study of the figures shows that in the summer months of 1968 very high catches were obtained with different wind directions, while in 1969 the highest catches occurred when southwest winds prevailed. The air pressure of these winds was slightly higher than in 1968 and the precipitation moderate.

#### Thunder and catch

At Bunkeflo thundery weather occurred on altogether 13 nights in both years. It was accompanied by rain. The average deviation from the expected catch was almost the same as during other rainy nights. Nothing can be said about a possible influence of thundery weather on the catch.



### Fog and catch

Foggy weather was observed on 7 nights in spring and autumn. Both positive and negative deviations from the expected catch were noted. It was observed that the catch increased during foggy nights when the temperature was high and the wind velocity low. After correction, only two nights showed a positive influence of fog.

### Comparison between corresponding months in 1968 and 1969

#### June (figs. 41<sup>x</sup> and 42).

- (1) In June 1968 the mean night temperature was very high compared with the 30 years mean for the area (table 8). The regression on the mean night temperature was also significantly negative. In June 1969 the mean night temperature was also high but lower than in June 1968 and no significant regression was noted in the 8 factors calculation.
- (2) The maximum day temperature was high in June both in 1968 and in 1969, though highest in 1968 (figs. 39,40). The day temperature range was greater in 1969 (table 8) and positively correlated to the catch (fig. 42). In 1968 a significantly negative regression was noted on the maximum day temperature but none in 1969.
- (3) The day wind velocity in June 1968 was stronger than in 1969 (table 8) and a negative regression on the border of significance was found.
- (4) In June 1968 the monthly precipitation was almost twice the normal (110 mm against normally 56 mm). In 1969, on the other hand, this month was very dry, only 30 mm being measured. No rain fell during the warmest period of the month. On the mean day vapor pressure deficit a very strong negative regression was noted. The catch did not increase until the 17th, when 0.5 mm rain fell, despite the fact that the day and night temperature had been high from the 9th (figs. 13,40). This rainfall was the first registered in June 1969. In June 1969 rainfall had a strong positive effect (table 19).
- (5) In June 1968 the mean night wind velocity was as high as 2.3 m/s but no significant regression was found on this factor in the 8 factors analysis. In June 1969 the minimum night wind velocity showed a significant negative correlation to the temperature range of the night. This indicates that the night wind prevented the temperature from falling. Also in this month no significant regression was found on the mean night wind velocity.
- (6) In June 1968, 6,858 noctuids were caught against only 4,594 in June 1969. As both months had a mean day and night temperature above normal and almost

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<sup>x</sup>) The signs in the partial regression diagrams in the figures represent from the left to the right for every factor the 3 factors analysis, the 6 factors analysis and the 8 factors analysis.





the same in both months, the main difference was that while in June 1968 there was a heavy precipitation, June 1969 was extremely dry.

July (figs. 43, 44).

- (1) The mean night temperature was very low in July 1968, the comparatively lowest of all month tested. The significant positive regression on this factor was also the strongest regression on the mean night temperature found in any month (table 11). In July 1969, when the mean night temperature was high, no significant regression on this factor was found.
- (2) In July 1969 the mean day temperature was the second highest measured. On this factor a significant negative regression was found but none in July 1968.
- (3) The mean night wind velocity was higher in 1969 than in 1968. Despite this, only in 1968 was a significant negative regression found on this factor. On high mean night wind velocities, however, a weak significant negative regression was found in 1968 and 1969.
- (4) The precipitation in July 1968 was very heavy (138 mm against normally 65 mm). The daily rainfall was negatively correlated to the day and night temperature, which indicates that most of the rain was cold. In July 1969 the monthly precipitation was almost normal and positively correlated to the temperature. In July 1968 rainfall has a strong negative effect on the catch (table 19).
- (5) In July 1968 a great number of significant correlations between different weather factors and between weather factors and the catch was noted. The number of significant regressions on weather factors was also higher than in 1969 and the regressions were on the average stronger in 1968 than in 1969. In 1969 no significant correlation between weather factors and the catch were noted.
- (6) While July 1968 was very cold and rainy, July 1969 was very warm and there was normal precipitation. The catch in 1968 was 8,820 noctuids against 11,515 in 1969, the highest monthly catch registered.

August (figs. 45, 46).

- (1) In August 1968 the day and night temperature was almost normal, in August 1969 higher than normal. The mean night temperature, however, was almost the same in both years and quite normal for the month. In both months a significant positive regression was found on the mean night temperature, stronger in 1968 than in 1969. Windy weather was significantly negatively correlated to temperature in 1968 but positively correlated to the mean night temperature in 1969.
- (2) In August 1968 less rain than normal was registered (52 mm against 76 mm), while in August 1969 the figure was above normal (106 mm). The mean day vapor pressure deficit in August 1969 was the highest registered but no significant negative regression was noted. During the period at the beginning of the month





in 1969, however, with high vapor pressure deficit, there was only a small amount of rain (fig. 40). High day vapor pressure deficit showed an insignificant negative regression.

(3) In August 1968 a rather strong negative regression was noted on the mean day temperature but none in August 1969, despite the fact that in this month the mean day temperature was the highest recorded for any month. In 1968 no rain fell during the period with high temperatures whereas in 1969 a small amount of rain fell during the warmest period (figs. 39, 40).

(4) On the mean night wind velocity, a strong negative regression was found in 1968 but none in 1969 though the mean night wind velocity was almost the same in both years. In 1968, however, windy weather occurred in connection with low temperatures, in 1969 with higher night temperatures (see above 1).

(5) In both years the variance explainable by the weather factors tested was rather high but higher in 1968 than in 1969 (90 against 78 per cent).

(6) The main difference between the two years was that in August 1969 the precipitation was heavy while the rainfall in 1968 was less than normal. August 1969 was also on an average slightly warmer than August 1968. In the latter year, however, a second warm period occurred at the end of the month with no counterpart in 1969 (figs. 39, 40). The catch in August 1968 was 6,987 noctuids against 5,895 in August 1969.

## 2. Diel distribution of catch

As is evident from fig. 23, the curve on the yearly diel distribution of catch shows a very symetric course. The aim here is to investigate whether weather factors had any influence on this curve.

Out of the weather factors measured every hour during the night, only the temperature and the relative humidity show any clear nocturnal trend (falling temperature, rising relative humidity). As the relative humidity in the earlier analyses proved to have a negligible influence on the catch, this factor has not been taken into account here. An increasing relative humidity during the night is due to falling temperature and does not affect the absolute humidity or the vapor pressure deficit unless saturation point is reached. In contrast to the night temperature the night wind velocity and the nocturnal rainfall have no regular trend. These factors therefore, are of interest only for the study of the diel distribution of catch during individual nights.

It seems that the only weather factor that may have any influence on the monthly and yearly diel distribution of catch is the night temperature.



### Temperature and diel distribution of catch

Fig. 25 shows the nocturnal distribution of catch during different months of the two years. No correlation between the night temperature and the distribution of catch is noted for the months June 1968, June 1969, July 1968, July 1969, and August 1969. If the temperature had been the factor controlling the nocturnal distribution of catch in these months, the highest catches should have occurred in the first part of the night. This is not the case. On the contrary, the catch is symmetrically distributed around midnight. Later in the year, however, this symmetric curve is smoothed out and becomes better correlated to temperature. This trend is noted in August 1968, more pronounced in September of both years, and strong in October of both years. As can be seen from figs. 23 and 25 the curve on the yearly nocturnal distribution of catch shows the same pattern as the curves in the summer months, when the majority (90.4 per cent) of the noctuids were caught.

In fig. 47 the monthly correlation between the catch and the temperature for each hour of the night has been calculated. The correlations become stronger the later in the night the catch takes place. In the months with high temperatures, such as August 1968 and July 1969 the correlation between catch and temperature is very weak. Only the last hours of the night, with lowest temperatures show a significant positive correlation. In months with low temperatures, such as September of both years, the correlation between catch and temperature is strong and positively significant almost all night. In months with moderate temperature, such as June of both years, no significant correlation is noted in the first hours of the night, while a significantly positive correlation is found in the later hours. It should be observed that one certain hour in August 1968 and July 1969 show a significant negative correlation between the catch and the temperature.

In fig. 48 the difference in catch between the hour 2300 - 2400 and the hour 0100 - 0200 and the corresponding difference in temperature are presented. A decrease in temperature causes a stronger decrease in catch when the temperature is already low. Thus, a temperature fall in June 1968 from  $9.5^{\circ}\text{C}$  to  $9.0^{\circ}\text{C}$  caused a decrease in catch of 80 per cent, while in the same month 1969 a fall from  $17.0^{\circ}\text{C}$  to  $14.5^{\circ}\text{C}$  caused a decrease of only 10 per cent.

To summarize, the correlation between catch and temperature is stronger if the temperature is low.

### 3. Change in catch of species

The number of species and the distribution of individuals on different species has been discussed earlier. The influence of weather factors on the change in catch of species is here analysed in the same way as the influence of weather





factors on the change in catch of individuals. The same method as in the previous 3 factors analysis has been used and the same factors have been tested (mean night temperature, maximum day temperature, and mean night wind velocity).

Results (figs. 49, 50, tables 20, 21).

As evident from fig. 49, the regression curves of species correspond well with those of individuals. This applies to all three factors tested. However, with very few exceptions, the regressions on the weather factors tested are weaker for species than for individuals. Thus the influence of weather factors on the change in catch of species seems to be smaller than that on the change of individuals.

The mean night temperature and the mean night wind velocity seem to have had the strongest influence also on species while the maximum day temperature seems to have been of little importance. It was found in the previous analyses that weather factors had a stronger influence in 1968, when the temperature was lower than in 1969. The same is the case here but the influence of weather factors in 1969, judging by the small number of significant regressions, seems to be even smaller on the change in catch of species.

The curves on the variance explainable by the three factors tested closely follow the curves on the explained variance in the catch of individuals (fig. 50). The variance explained is slightly smaller for species than for individuals both in 1968 and 1969 (1968: 46 per cent against 54 per cent, 1969: 29 per cent against 33 per cent). The differences, however, are not significant.

A question of great interest is if different species react in different ways to the influence of weather factors. However, in this study no consistent investigation of this kind has been performed. This is mainly due to the fact that rather narrow flight periods, the strong seasonal trends within these, and the very different weather and light conditions prevailing during different flight periods, make every comparison unreliable. The influence of wind on the flight capacity was tested, however, in some experiments in 1969 and it was then found that small species were more sensitive in this respect (fig. 58). Nothing can be said from the results about the influence of the wind on individual species. Here, only the possible influence of weather on the change in catch of some common species from 1968 to 1969 is briefly discussed.

The number of individuals belonging to some of the more common species was subject to great changes from 1968 to 1969. As can be seen from table 22, some species were more frequently captured in 1968 and others in 1969. The differences between the two years were very great for some species. The catch of Plusia gamma (fig. 51) in 1968 was more than three times larger than that





in 1969 (3,609 against 1,164 ind.). This is probably at least partly due to the fact that the temperature, notably the maximum day temperature, and the vapor pressure deficit during the flight period in 1969 (table 8, fig. 40) were so high. During the most important part of the flight period, August 1st to 10th, the maximum day temperature was on an average  $27.5^{\circ}\text{C}$  and the vapor pressure deficit 9.1 mm Hg. Temperatures above  $32.5^{\circ}\text{C}$  in connection with vapor pressure deficits of 13.8 mm Hg were registered. It is possible that this gave rise to a very high death rate and thus kept the catch of the species low. However, as Plusia gamma is partly an immigrant and great changes in the number of this species is common, also other factors than the actual local weather may have had an influence on the change in catch from 1968 to 1969.

The catch of Agrotis exclamationis, in contrast, was much higher in 1969 (table 22). The flight period was also slightly later than in 1968 (fig. 53). This was probably due to the very low temperature prevailing in the first part of June 1969 (fig. 40). Minimum night temperatures of  $4.5^{\circ}\text{C}$  were recorded. The delay of the flight period in 1969, on the other hand, also caused the species to fly during the very favourable weather conditions prevailing in the last part of June and first part of July. This is probably the reason for the higher catch of A. exclamationis in 1969, especially as the last part of the flight period in 1968 coincided with very bad weather conditions (July 1968, fig. 39).

Rhyacia c-nigrum supplied higher catch figures in 1969 than in 1968. The flight period of the first generation in both years occurred in July. In July 1968 the average temperature was much below normal (table 8). This gave rise to a smaller catch than in July 1969 (fig. 52). The second generation was also larger in 1969 due to the higher average temperature in October 1969 as compared with October 1968.

The catch of Triphaena pronuba in 1968 was almost twice that of the same species in 1969. As can be seen from fig. 55 it was especially in the middle of the flight period that the catch was lower in 1969. This occurred at the end of July and the first part of August when the temperature in 1969 was very high (fig. 40).

No significant differences between the sexes were found as regards the change in catch from 1968 to 1969 (table 23). The relative abundance of females in the catches of A. exclamationis, P. gamma, and T. pronuba was almost the same in both years, although the size of the catches varied greatly. As to R. c-nigrum and R. rubi, the two species having two generations every year, the number of females in the catch was insignificantly higher in the year when the catches were highest (1969).

Thus it is rather probable that the differences found as regards the size of the catch of individual species between 1968 and 1969 are at least partly



due to different weather conditions during the actual flight period. The possibility cannot be disregarded, however, that also weather conditions during the year before the catch, including winter, may have an influence on the size of the stocks by affecting egg-laying, larval development and hibernation.

The great changes in the catch of individual species do not, as a rule, affect the size of the total catch of noctuids, because as the catch of one species decreases the catch of another species usually increases. Thus, both in 1968 and in 1969, the ten most abundant species were together responsible for about 60 per cent of the total yearly catch.

## II. LABORATORY OBSERVATIONS

In the summer of 1969 a number of observations and experiments were carried out on captured noctuids in order to test tendencies found during the catch. The moths tested were kept in nylon cages of the same type as those used in the flight start observations (fig. 60). The experiments and observations took place under as natural conditions as possible. Most of the experiments were performed outdoors, some of them during the night. However, it can never be avoided that insects kept under unnatural conditions are subject to a stress situation and this should be kept in mind when evaluating the result.

### A. Observations on the influence of wind

The experiments were undertaken in order to find the maximum wind velocity at which the moths are capable of flying, and also to investigate possible differences between large and small species<sup>x)</sup>.

The experiments were performed outdoors in a calm place near the normal catching place and in normal night light. As the source of wind an ordinary vacuum cleaner was used. The air current from this blew along a plank on which a nylon net cage with the moth was exposed. The different wind velocities along the plank were determined, by means of an anemometer covered by the same nylon net as that on the cages, and then marked as a scale on the plank with white lines (fig. 87). By moving the cage from line to line the moths to be tested could be exposed to different wind velocities. The order of exposure was chosen at random. The steadiness of the air current was continuously tested by means of the anemometer. The fluctuations never exceeded 0.4 m/s. The temperature in the cage was continuously measured, as also the relative humidity in front of the cage, the latter by means of a psychrometer. The temperature in the air current near the vacuum cleaner (8 m/s)

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x) small species<sup>1</sup> = wing expanse 25-35 mm, large species = wing expanse 36-58 mm





exceeded that in the air current further away (1 m/s) by 0.5 - 1.0°C. The moths used were captured in the light trap, put into cages and immediately used for experiments. They spent two minutes in each wind area, and the number of seconds they were flying was observed. After two minutes in calm they were exposed to another wind velocity, and so on. All moths not flying continuously when under calm conditions were excluded from the experiment. Out of 100 moths tested only 30 were useful. On some nights all experiments failed. It was observed that the intensity of flight in individual moths was much higher after days with high temperatures than after days with low or moderate temperatures.

Several objections to the method can be raised. Normally the moths are not subject to such abrupt changes between calm and windy conditions. Because of shelter from vegetation in the area they are not, except for Plusia gamma, normally exposed to steady high wind velocities for such a long time as two minutes in succession.

### Results

The flight activity became successively less as the wind velocity increased. This tendency was found for both small and large species (table 24, fig. 58). However, while the activity for small species almost ceased at 4 m/s, the larger species were flying up to 5 - 6 m/s. Plusia gamma, a species tested separately on account of its known capability of flying long distances, was able to fly even at 7 - 8 m/s.

### B. Observations on the influence of light

#### (a) Start of the flight activity

In order to gain some information as to the factor or factors releasing flight activity, continuous observations at the time for the first flight start in the evening were performed in spring, summer and autumn.

#### 1. Observations in 1969.

The observations were made on captured moths. Each individual was kept in a special cage covered with nylon net (fig 60). The cages were built in such a manner that they gave good shelter against direct insolation, wind and rain, but were open enough not to give a different micro-climate from that on surrounding shady places. This was checked from time to time by means of a thermometer and a hygrometer. The cages were placed in rows, at five cm distance from each other, in a place near the normal catching place (fig. 2). There were no indications that the moths stimulated one another to flight. On May 7th and 9th half the cages were placed at five metres distance from each other and half, as before, at five cm distance. No difference was found between the two groups as regards start of flight. Fig. 61 shows how the





cages were normally arranged.

Every night during the observation periods the time of the first flight start was registered. At the same time the changes in light were measured close to the cages by means of a lux-meter. This was always directed towards the same spot in the sky. Weather factors such as temperature, rainfall, humidity, and wind velocity were also measured, the relative humidity by a hygrometer and sometimes by a psychrometer. Rainfall and wind direction were registered by the normal equipment on the catching place. Half an hour after the last moth had started, the moths were given a glucose solution. The moths selected for the observations were of different ages, because new moths were continuously added to the stock as older ones died. For the same reason the number of moths observed changed from evening to evening. They were selected in such a way that their composition as regards species and individuals reflected the composition of the actual catch (table 27).

### Results

All moths started within a narrow period of about half an hour in the latter part of the twilight period (figs. 62, 63). The factor inducing them to start was light or decreasing light. Most moths started within a narrow light zone of 10 to 1 lux (fig. 63). Bad weather did not inhibit the start. Obviously the impulse to start caused by certain light conditions was strong. However, if the weather was very bad, with low temperatures, strong winds, and cold rains, the moths returned to their shelters rather soon after start, normally within half an hour.

In spring and autumn the moths started their flight at a somewhat lower light value than in summer (figs. 63, 64). The majority of the flight starts in spring and autumn took place within a time period of about 25 minutes before darkness. In summer the starting period was more prolonged but this, of course, is also true of the twilight period itself. However, if the starting period is put in direct relation to the light, the moths started at a lower light value in spring and autumn than in summer: in spring within a light zone of 10 to 1 lux, in summer between 25 and 1 lux (table 28).

As a consequence of the general pattern shown above, the moths started earlier in the evening on cloudy nights than on clear nights. Fig. 65 gives a more detailed picture of the flight start for some species flying in spring. Note the early start on May 7th when the weather was thundery. Some individual specimens are represented in fig. 66. They followed the changes of light during their whole lifetime as adults.

Fig. 67 gives a picture of the flight starts in relation to weather factors. There is a small tendency for low temperatures to make the moths start later (at a lower light value), while temperatures above the normal make them start



earlier (at a higher light value).

A small difference in the time for flight start has been found between some species flying in spring (table 29, fig. 65). Monima gothica starts at a lower light value than Monima incerta and especially Monima stabilis. Species flying in summer start at a higher light intensity (table 30) and species flying both in summer and autumn start at a lower light value in autumn. No difference as regards flight start was found between males and females.

## 2. Observations in 1970

In order to test whether temperature has any influence on the flight start, the following experiments were carried out in the spring of 1970 on the place for the earlier start observations. Two big glass boxes were used, (the same as in the moonlight experiments, see fig. 71). In each of the boxes, 8 nylon net cages were placed with one male Monima incerta in each. One of the two boxes was heated by means of an ordinary hair drier blowing warm air into the box. The current was directed in such a way that it did not hit the cages with moths. The other box had the normal outdoor temperature. The temperature in the heated box was regulated by moving the glass lid in such a way that it covered a greater or smaller part of the box. The relative humidity in the boxes was continuously measured by hygrometers. It was no problem keeping the temperature in the heated box fairly constant. However, it proved impossible to keep the same temperature in all parts of the box, the difference between different parts being normally  $2^{\circ}\text{C}$ . The light was measured by a lux meter. As the boxes were placed beside each other so that both had the same exposure to the light, the only difference between them was that one had a higher temperature and lower relative humidity. As the relative humidity in earlier investigations has proved to have an insignificant influence on the activity within the present limits, the difference between the two boxes in this respect has been ignored. The moths tested were captured the night before, used for two nights and then replaced by others. The moths tested in the heated box the first night were tested in the box with normal outdoor temperature the next night and vice versa. They were given a glucose solution after the experiment was finished. Individuals that were to be tested in the heated cage were kept in a light room at a temperature of  $20^{\circ}\text{C}$  during the preceding day. This was done in order not to expose the moths to a converted temperature range, as the outdoor temperature during the day was normally below that in the heated box. The moths tested in the unheated box were exposed to the normal day temperature. The experiments started one hour before the beginning of the twilight period.

## Results

Moths kept in the heated cage started flying at a higher light value than





moths kept at outdoor temperature (fig. 68). The difference between the two groups is significant on all the seven occasions on which the experiment was performed. As the same moths were successively exposed to both high and low temperatures (see above) the difference cannot be ascribed to individual differences.

### (b) Actograph experiments on the influence of light.

#### Apparatus and technique.

The actograph. The instrument used in these experiments was a modification of one constructed by Sylven (1958). The moths were kept in a glass jar covered by a plexiglass disk (fig. 69). A stiff nylon-net cylinder hung down into the jar, connected to a grass straw, attached to a wooden stick resting on two razor blades. Perpendicularly to the wooden stick and attached to its mid-point was a cross bar with an ordinary pen nib in one end, and a movable rubber weight in the other. When flying, the moths touched the nylon net cylinder and the movements were transferred to the pen nib. The movements of the nib were registered on a drum driven by a twenty-four hours synchronous motor (fig. 70). In the outdoor experiments two drums were used. Attached to each of them four actographs could be used simultaneously, the entire equipment being kept in a big glass box with a loose glass lid, in order to prevent the disturbing effect of wind on the registrations. The glass in the two boxes was selected to allow as high a light transmission as possible. In the outdoor experiments the temperature was measured by thermometers connected to the actographs and the relative humidity by means of hygrometers in the boxes.

#### The light measuring equipment

The light was measured by means of a sensitive microphotometer connected to an electronic recorder (see page 11).

### 1. Influence of natural light

#### Normal night light in June

The experiments were performed in 1970. In order to avoid disturbing light from street lamps and buildings, the experiments were carried out in an agricultural district 1 km south of the normal catching place. In June, notably around midsummer, the northern part of the sky is rather bright all night. The glass boxes with actographs were therefore placed in an open field where the northern part of the sky was well visible to the animals in the actographs (fig. 71). In the experiments on June 11th, 12th, and 13th, both boxes were uncovered until 2400. Then on one of the boxes, the northern side and parts of the western and eastern sides were covered with black paper so that only light from above and from the south could reach the moths. In the experiments





performed on June 14th, 15th and 21st, one of the boxes was covered in this way all night while the other box remained uncovered. All the moths tested belonged to Agrotis exclamationis, the most common species during the period. Most of the moths were males but on June 13th and 14th some females were also tested. Every night new moths were used.

#### Results (figs. 72,73,74).

The figures show that on some nights the light seems to have had some influence on the activity, on other nights none. Thus on June 11th and 13th three moths out of five responded to the covering at 2400 hours with greater activity during the later part of the night. The increase in activity cannot be due to temperature which fell during the night. At the same time the uncovered moths were comparatively inactive. On June 12th, however, no response to the covering was noted. On June 15th, the activity of the moths in the covered box was clearly greater than that of the moths in the uncovered box. In the last experiment, on June 21th, all moths, both covered and uncovered, showed great activity all night. The temperature that night was much higher than the nights before.

#### Moonlight.

Hosney (1953) tested the influence of moonlight on the catch by means of an indirect method. For each night he calculated the size of the catch if the night were to give an average for the month in question. This he did by multiplying the deviation in weather factors from their monthly means with the corresponding partial regression values. The corrected log. catch figure was then compared to the actual log. figure of the night. The tested nights were then put into groups with regard to the moon cycles (no moon, first quarter, full moon, second quarter).

The method used by Hosney has certain disadvantages. At Bunkeflo it was found that many factors affect the intensity of moonlight. Clouds may cover the sky and prevent the moonlight from reaching the ground. Warm air with low visibility lowers the light intensity of the moon. If the moon stands near the horizon the light from it is much weakened. On one occasion a full moon standing only  $10^{\circ}$  above the horizon had a light intensity of only 0.02 lux, while on another occasion a half moon standing  $45^{\circ}$  above the horizon gave 0.17 lux. In the first case the air was warm and visibility low (no clouds) while in the second case the air was cold and visibility good.

On half-cloudy nights or on nights with thin cirrus clouds, the moonlight may be reflected by the clouds and a great part of the sky will be illuminated. At Bunkeflo, the strongest moonlight was found on clear cold nights with a full moon high above the horizon. This situation is more common in spring and autumn than in summer. All these aspects should be regarded when evalua-



ting the method presented by Hosney, which therefore seems too schematic. Thus it seems that the best method of testing the influence of moonlight is by continuous observations of the activity of captured moths under moonlight conditions.

No observations on the influence of moonlight on the catch were made during the two relevant years. Neither has the method used by Hosney been applied, because of the disadvantages pointed out above. At Bunkeflo, direct observations on the influence of moonlight on noctuids kept in actographs were performed in 1970, with simultaneous registration of the moonlight intensity. The same method as in the night light experiments was used. In measuring the moonlight, the photo-cell head was directed towards the moon. These experiments were carried out in May, June and August 1970 1 km south of the normal catching place, while in July of the same year the weather conditions were too bad.

May 1970. The experiments took place on May 15th and 16th. Moths belonging to different species, mainly Monima were used. Because of the very low night temperature, the boxes with the actographs had to be heated. This was done by means of the hair drier used in some of the flight start experiments but it proved impossible to keep the temperature constant, due to the falling outdoor temperature. The values are given in fig. 75. Every second half hour the boxes were covered against the moonlight but in such a way that the temperature was not affected. Due to the low temperature, there was very little activity among the moths tested. However, the moths reacted to the covering with a rise in activity. They also reacted to very small differences in light.

June 1970. Agrotis exclamatoris. In these experiments no heating of the boxes was necessary.

1: June 16th (fig. 76). Both boxes were covered on all sides between 2200 and 2300. One of them was also covered from 2400 to dawn. When not covered, both boxes were exposed to the moonlight and also to the light from the northern horizon. The moths responded to the first covering with greater activity. In the later part of the night, two of the moths in the covered box responded to covering with greater activity, while the exposed moths showed little activity. However, as the moon disappeared before 0100, this must have been due to the influence of the light at the northern horizon. The moths in the uncovered box responded well to the decrease in light caused by the disappearance of the moon behind a tree.

2: June 17th (fig. 78). The boxes were both covered against the light from the northern horizon. One of the boxes was also covered against the moonlight all night. Due to the low night temperature, there was little activity in both boxes. However, the activity in the covered box was greater than in the





box where the moth were exposed to the moonlight. Here, too, there was a response to the decrease of light when the moon went behind a tree.

3: June 18th (fig. 77). Same experiment as the previous night. Due to the higher night temperature, the activity was greater, notably in the covered box.

August 1970. *Triphaena pronuba* (fig. 79). This species has a robust body and is thus well fitted to actograph experiments. One box was covered against the moonlight, the other uncovered. During both nights there was patchy cloudiness alternating with clear periods. Visibility was good. The clouds consisted of well-defined cumulus, and when a cloud covered the moon the light diminished perceptibly (from 0.17 lux to 0.01 lux) and very quickly (within one minute). On August 17th there was little activity in both boxes while the following night it was slightly greater; on both nights it was greater in the covered box. More important, however, was that the moths in the uncovered box responded strongly and rapidly to the decrease in light caused by the clouds.

#### Experiments with males and females.

In order to test if there is any pronounced difference between males and females as regards diel flight activity some actograph experiments were carried out in the summer of 1969. They were performed in a room where the conditions as regards temperature and relative humidity were almost the same as in the catching area. All the windows were kept wide open, except for one behind which the actograph was placed, in order to expose the moths to normal night light. Eight males and eight females belonging to the species *Agrotis exclamationis*, *Rhyacia c-nigrum* and *Triphaena pronuba* were tested.

Results. The flight activity of the males was fairly evenly distributed over all hours of the night (fig. 80). The females, on the other hand, showed two activity periods: one more pronounced, between 22.00 and 23.30, and one between 01.00 and 02.00. Around midnight the females were very inactive. The same diel distribution of female activity has also been found in the catch during some summer months, both in 1968 and in 1969 (fig. 25).

## 2. Influence of artificial light.

### (a) Artificial twilight experiments.

In order to investigate if noctuids could be forced to start their flight activity under the influence of artificial twilight, the following two experiments were performed in the summer of 1969.

On June 24th, some hours before twilight, five *Agrotis exclamationis* (males) in a nylon net cage were brought in from the daylight and placed in a room lighted by a clear 60 watt bulb. The bulb was connected to a light variator (Bush dimmer 2000 sp.Jvw) and the light intensity of the bulb could thus be gradually reduced or increased. The moths were allowed to adapt themselves to the



somewhat lower temperature prevailing in the room ( $19.5^{\circ}\text{C}$  against  $24.0^{\circ}\text{C}$ ). After two hours, twilight was imitated by means of the variator and a lux meter.

The results are given in table 31. The moths behaved as if they were subject to normal twilight.

The first experiment took place some hours before the normal twilight period. In order to see if the moths could be induced to start their activity at a completely different time, the same experiment was repeated in the morning of July 3rd. The moths used in this experiment had been kept in a room with the same temperature as in the experimental room with light from a 60 watt bulb. The results are given in table 32. Even in the morning the noctuids could be induced to start their flight activity by artificial twilight.

(b) Experiments on photoperiodic entrainment of the diel rhythm.

The experiments were performed in July and August, 1969, in a basement room with rather constant temperature and relative humidity which were continuously checked. The former varied between  $17.8^{\circ}\text{C}$  and  $18.6^{\circ}\text{C}$  and the latter between 67 per cent and 78 per cent. No external light could reach the room and a light sluice was built in order to ensure this. The light source was the 60 watt bulb used in the twilight experiment. All changes from light to darkness and from darkness to light were arranged in the form of artificial twilight and dawn periods. During the photophase the moths were exposed to a light intensity of 100 lux.

The moths used in the experiments were all males of Triphaena pronuba, one specimen in each experiment. The animals were tested during their whole adult lifetime. They were fed with a glucose solution continuously dripped on to a cotton wool pellet attached to one of the ventilation holes in the plexiglass disk covering the jar in the actograph. This arrangement was made in order to avoid that the feeding should have any phase-setting effect on the activity.

Results.

The results of the experiments are given in figs 81 and 82. When moths were exposed to both light (photophase) and darkness (scotophase) their activity was confined to the darkness, except for some sporadic movements in the photophase (experiments 2 and 3). This was the case even if the period of darkness occurred in daytime. If the moths were kept in total darkness, the time for the activity period was dependent on the time at which they had previously been exposed to twilight. If this had occurred in the evening the moths were active during the night (experiment 4 and 5), but if the twilight had been arranged in the morning, they were active during the artificial scotophase in daytime (experiment 6). In the latter case, however, they were also slightly but evidently active during the night. If the moths were kept in constant light no activity occurred during the first 24 hours. Then they were most ac-





tive during the night, but to a certain extent also in the daytime (experiment 7). If the moths were exposed to a dark day and then kept in full light, they were active only during the day. (experiment 8).

### (c) Artificial moonlight experiments.

In order to test if the negative effect of moonlight could be obtained by substituting another source of light, some artificial moonlight experiments were performed in July, 1970. These took place in a dark room. The moths tested belonged to the species Parastichtis monoglypha and Triphaena pronuba. The actographs used in the true moonlight experiments were used. An ordinary clear 40 watt bulb was placed at 3 m distance from the actographs, the angle between the bulb and the table with the actographs being  $45^{\circ}$ . The bulb was built into a cylinder having a diameter of 10 cm and anteriorly covered by a milky glass. By means of the light variator used in the twilight experiments it was arranged that the light reaching the moths had an intensity of 0.17 lux, the same as bright moonlight. The bulb was connected to an electric clockwork with the effect that the hours of the night were alternately dark and light. The results are given in fig. 83. The moths tested were active both in light and darkness but mostly in darkness (except for one moth which flew all night).

### C. Observations on the diel egg-laying activity.

It had been observed that females kept for flight start observations at Bunkeflo very frequently laid their eggs in the cages rather soon after the twilight period. However, a check on individual females in order to map the diel distribution of egg-laying would be difficult and also too laborious. It seemed obvious that the construction of some kind of automatic recording apparatus was necessary.

Sylvén (1958) used such an apparatus in his investigations on fruit leaf tortricids. However, this could only be used for one female at a time. In order to achieve a sufficient basis for statistical calculations it was desirable to study several females simultaneously.

It was observed, that females kept for egg-laying in glass jars almost without exception laid their eggs on the nylon nets covering the jars. They put their ovipositors through the nets and attached the eggs to the outside. These observations formed the basis for the construction of the egg-laying apparatus. The egg-laying recording apparatus (fig. 85).

The apparatus was built on a 1.5 meter high stand in order to be easily accessible for observations (fig. 88). Two 45 cm high drums, one of which was driven by a twenty-four hours synchronous motor, carried a nylon net. One of the drums could be adjusted by two correction grooves in such a manner that



the net was always kept stretched. Sandpaper glued to the drums prevented the net from slipping. When the motor was in use, the net was kept moving at a constant speed. Ten females could be tested in the apparatus at the same time. On each side of the apparatus, five females were kept in small cages connected with a stand. Tests on the minimum space necessary for successful egg-laying had been made in advance. The width of the hole in front of the cages was adjusted to correspond to half the distance the net moved in one hour. This arrangement made it possible to count the number of eggs laid per hour. On both sides of the front holes, round polished metal rods were attached in order to make it easy for the net to pass the cages. The two stands with the female cages could be pressed against the net so as to prevent the females from escaping. The pressure could be controlled by means of correction grooves. The females put their ovipositors through the net and laid their eggs on its outside. This was important, because it prevented the eggs from being crushed by the metal rods. Thus as the net passed the holes in the cages, the eggs were laid on it and then followed the moving net away from the cages. The distance between the cages and the drums was such that the first laid eggs did not reach the drums. By means of a movable egg-counting stand the number of eggs laid by each female per hour could be counted. The eggs were then removed from the net. This task was carried out every morning during the period of observation. The temperature in the cages was controlled from time to time. The stand with the apparatus was covered by a plastic roof, in case of rain, and the construction was intentionally very open in order to allow weather factors (except for rain) to influence the females tested. The apparatus worked both day and night.

#### Results (fig. 86, table 33).

In June and July 1969, 53 females were tested in the egg-laying recording apparatus. Of these, 48 belonged to *Agrotis exclamatoris*, The commonest species at the time. 42 females laid eggs but two deposited them in the cages and were disregarded. Altogether over 2400 eggs were laid, the majority in the early part of the night. A second but smaller peak in the egg-laying activity occurred between 0100 and 0200, while only few eggs were laid during the darkest part of the night. The number of egg-laying occasions followed the same pattern, though less pronouncedly so. Only two of the females took longer than two hours to lay their eggs.

#### D. Observations on the influence of weather factors on the longevity and hatching of noctuids.

In the analyses presented earlier, it was found that even day weather factors may have an influence on the catch of noctuids. The mean day temperature





may show either a positive or negative significant correlation and a high day maximum temperature may have a negative influence. Also rainfall the day before the flight may affect the catch.

It is quite understandable that a low mean day temperature gives rise to a low flight activity because it is so strongly correlated to the night temperature. It is also natural that cold rains have a negative effect. It is, however, more difficult to explain why high mean day temperatures and particularly high maximum day temperatures should have a negative effect. In the wind velocity experiments it was observed that the intensity of flight of individual moths was higher after days with high than after days with moderate or low temperatures. This observation hardly indicates that high day temperatures should have any negative influence. Nevertheless, in the analyses clear evidence is found that high day temperatures may have a negative effect on the catch of noctuids.

The use of light trap catches for studies on flight activity is based on the assumption that these catches directly reflect the flight activity of night-flying insects. However, it must be strongly emphasized that changes in the catch of noctuids are not necessarily due only to changes in the flight activity of moths present in the area. There is no doubt that weather factors also affect the number of moths available to catch, because they may have an influence on the hatching of adult moths and also on their death-rate. As a consequence, at least part of the changes in light trap catches may be due to changes in the number of moths available, changes caused by weather factors.

In a study on the flight activity of noctuids, based on light trap catches, it must therefore be regarded as justifiable to investigate the influence of weather factors on the number of moths present, notably in cases where the size of the catch cannot easily be correlated to the flight activity alone.

The observations and experiments presented below have been carried out for this purpose.

#### Length of life after capture.

The length of life after capture was recorded for the moths kept for flight start observations and for egg-laying, both in spring and summer. Normally, when death occurred they fell down on the floor of the cage. However, it happened from time to time that dead moths remained clasped to the cloth in their shelters. All moths not starting flight were therefore examined. The moths were checked before the twilight period every day and the day of death is included in the period of life after capture. The moths observed belonged to different species and were caught on different nights. Accordingly they were influenced by different weather conditions during their lifetime after capture and no comparisons could be made between different species as regards



length of life.

### Results.

The average lifetime after capture of moths investigated in spring was more than twice that of moths observed in summer (fig. 89). The figure shows negative correlations between the lifetime and the daily maximum and mean of temperature, notably in summer. During periods with high day temperatures (14 - 19.6) the moths only lived for two or three days after capture while a decreasing temperature immediately resulted in an increase of lifetime (19 - 23.6). In spring, the dependence on temperature was not so clear and the maximum temperatures in daytime were of course lower than in summer (average 12.1°C against 22.4°C). During the period with low temperatures in the later part of April and the first part of May, the moths studied were very inactive. Not only the temperature but also the wind was negative during this period. The moths used for the flight start observations also returned to their shelters very soon after flight start and remained there for the rest of the night. However, during this period the length of life after capture was the longest observed.

### Influence of weather factors on the death-rate.

In the observations presented above, the moths were of different age and had also been exposed to different weather conditions. In the following observations and experiments moths caught during the same night were used.

It was found that the death-rate of the moths observed was higher when the temperature was above normal than when it was low. In connection with dispersal experiments with marked noctuids in the summer of 1966 at Bunkeflo, 300 moths were kept in cages as a control group. During an extremely hot day with maximum temperatures well above 30°C and wind velocities of 6 to 8 m/s, these moths with few exceptions died within a period of a few hours.

As a result of these observations, a number of experiments on the influence of weather factors on the death-rate of noctuids were carried out from June 16th to July 5th, 1969. At the same time the death-rate of newly captured moths kept in cages was observed.

### Observations on the death-rate of newly captured moths.

Every night during the observation period, noctuids were captured at Bunkeflo by means of a light trap in a place situated outside the normal catching place. The newly captured moths were placed in a nylon net cage of the same type as that used in the flight start observations, but much bigger. The moths in the cage were protected from direct insolation and rain but were under the influence of the same weather conditions as in other shadowy places in the neighbourhood. Every night new moths were captured and thus they were only observed for one single day. Before twilight the number of dead moths was





counted and the living moths were released. As the moths were only kept for a day and not over-night, no water or food was given. The number of moths observed changed from day to day according to the catch the night before.

### Results.

The relative number of dead moths varied greatly from one day to another (fig. 90, table 34). The death-rate curve closely followed the curves for the mean day and the maximum day temperatures. There was also a good conformity between the curve for the mean day vapor pressure deficit and the death-rate curve, notably in the period June 24th to 27th when the mean day vapor pressure deficit was strongest. However, the curves for the mean day relative humidity and the mean day vapor pressure themselves showed no conformity with the death-rate curve. The death-rate was also significantly and positively correlated to the mean day temperature (fig. 91). As can be seen from the same figure it also follows the regression line on the same factor. A significantly positive correlation is likewise apparent between the maximum day temperature and the death-rate (fig. 93). However, the correlation is weaker for temperatures below 23°C. The correlation between death-rate and the mean day vapor pressure deficit is not so good as that between death-rate and different temperatures. If all days are considered, however, the correlation is significantly positive at the 5 per cent level (fig. 92).

### Experiments on the influence of weather factors on the death-rate of noctuids.

It was found during the observations on the death-rate of noctuids that high temperatures had a lethal effect, and also that high vapor pressure deficits negatively influenced the moths. Larsen (1943) found that the combination of a low relative humidity of the air and high temperatures during the night sometimes resulted in such a high saturation deficit that the activity of noctuids was distinctly reduced.

The temperature may affect the moths in several ways. High temperatures raise the basal metabolism of the animals and result in increased transpiration. They also affect other vital processes in the body of the insects. When the temperature is high at our latitudes, the mean day vapor pressure deficit also normally becomes high. As a result of this evaporation from the body surface increases. The water transport from the interior of the body to the surface is dependent on the vapor pressure deficit of the air in the narrow contact zone between the surface of the body and the surrounding air. The transpiration goes on until the vapor pressure in the contact zone equals the vapor pressure in the tracheal tubes. Due to the evaporation, the transpiration has to start over and over again. If the vapor pressure deficit in the air is small, these temporary stages of equilibrium are reached more rapidly than if it is high. Thus the transpiration also will increase when the



temperature is high, due not only to the higher basal metabolism but also to the higher vapor pressure deficit of the air.

If the above argumentation is correct windy weather in connection with high day temperatures should also have an influence on the evapotranspiration. During windy conditions the temporary stages of equilibrium in the contact zone will quickly be broken down and the more humid air repeatedly replaced by air with a higher vapor pressure deficit. This should have an accelerating effect on the transpiration. Thus, if it can be shown that the wind increases the negative effect of high day temperatures, it should also be indirectly regarded as proved that the real effect on the moths is that of desiccation.

#### The influence of wind on the death-rate of moths kept at a high temperature.

The experiment was carried out on June 17th during a period of stable high air pressure when the day temperature could be expected to become high. The night before, 24 males belonging to the most common species at the time, Agrotis exclamationis, were captured and put into two cages, 12 moths in each cage. In the morning, the two nylon net cages were placed on a spot well exposed to the sun but protected against wind. By means of an ordinary vacuum cleaner, one of the cages was exposed to a persistent air current the whole day while the control group of moths remained in calm conditions (fig. 94). In the front part of the cage exposed, the air current had a velocity of 6 m/s, while the rear part of the cage was exposed to 5 m/s. Such velocities sometimes occur in the summer in connection with high day temperatures. The wind velocity was controlled by means of an anemometer covered by a nylon net, the temperature in the two boxes by thermometers in the cages, and the relative humidity in the control cage by a hygrometer placed in the cage. The relative humidity in the exposed cage was controlled by means of a psychrometer immediately in front of the cage. The temperature in the exposed cage was slightly higher than that in the control cage and the relative humidity was somewhat lower (table 35). The differences between the two cages, however, were rather small. The temperature and relative humidity in the meteorological cage were also measured. Every half hour the moths in the two cages were observed and their activity registered.

#### Results.

As soon as the vacuum cleaner had started and the moths in the exposed cage felt the air current, great activity started (table 35). The moths flew vigorously and tried to escape from the current. It was possible for them to hide in strips of cloth hanging in the rear part of the cage but they remained active. After four hours, this desperate activity ceased and the moths settled on the bottom of the cage. One was already dead. The moths in the control group were less active. At the beginning of the day most of them remained





hidden in the cloth. In the afternoon, when the relative humidity was at its lowest, flight activity occurred also in this cage. The flight was, however, more normal and not so intense as in the exposed cage. After the end of the experiment all moths were given food and water and observed every night until they died. As they all received water, any difference between the two groups as regards lifetime, activity and number of flight starts must be considered due to differences in wind conditions on June 17th.

The moths earlier exposed to wind were less active, performed fewer flight starts and had a shorter lifetime than the moths not exposed to the wind (fig. 94).

#### The importance of access to water.

From the results of the experiments reported above it is obvious that the supply of water is very important to noctuids. This assumption is also confirmed by the results of an experiment carried out in May, 1969. 24 males belonging to Monima incerta were captured and put into two cages, 12 in each. The moths in one of the cages were given a glucose solution every night, while those in the other cage were not. The lifetime of the moths belonging to the two groups was observed and also their activity. As can be seen from table 36 and fig. 95 and 96, the moths given food and water lived longer and showed greater activity. Only the activity during the first three days, when all the moths were alive, has been taken into consideration.

#### Hatching of adult moths.

In order to investigate if the temperature has any influence on the hatching of adult moths and thus indirectly on the number of moths flying in the area, some breeding experiments were performed in the summer of 1969. Some moths hatched as adults in the autumn, and some in the following summer.

#### Results.

Only two hatches bred in summer under controlled conditions appeared as adults in the autumn of 1969. A very high percentage of the eggs laid by a Rhyacia c-nigrum female appeared as adults, against only 30 per cent of the eggs laid by a Barathra brassicae (table 37). However, from the same breeding of B. brassicae 14 moths were hatched in the summer of 1970! In the spring of 1970 one of the breedings of Monima stabilis also hatched. The entire breeding of Rhyacia plecta hatched in the summer of 1970. Thus out of a total number of 1699 eggs laid altogether 156 moths hatched as adults (9.2 per cent). If only the females which produced adult moths are counted, 66 per cent of the eggs laid hatched as adults, but adults were obtained from only 5 out of 36 females which had laid eggs. This small figure is probably due to the artificial conditions under which the breeding took place and nothing



can be said from the results obtained about the breeding and hatching in natural conditions.

Of the moths hatched, 52 per cent were females. This should be compared with the figure for the relative number of females in the catch where only 23 per cent of the total catch in both years consisted of females. Also Hosney (1958) found 23.5 per cent females in the catch in 1951 - 52.

The hatch of Rhyacia rubi in August 1969 occurred during a period with rather low temperature, while the hatches of R. c-nigrum and B. brassicae later in autumn the same year occurred when the temperature was comparatively high (fig. 98). The hatching of R. plecta in the summer of 1970 started very abruptly in connection with a sudden rise in the day and night temperatures. During the night of June 5th to 6th 51 moths appeared (fig. 99).

### III. DISCUSSION

In the preceding part of this paper the influence of a number of environmental factors on the flight activity has been investigated by field and laboratory observations. The results of the analyses and experiments indicate that this is a very complex subject. It is also obvious from the results that different factors co-operate and that the influence of one single factor is highly dependent on the influence of other factors affecting the activity at the same time. It has also been shown that different factors affect each other and that a factor without direct influence on the activity in a certain situation may have an indirect influence by affecting other factors with direct influence.

As a consequence of this it is impossible to arrange the factors investigated in a list of precedence with general applicability. This should be borne in mind when the relative importance of different factors is discussed. However, despite the above-mentioned reservations it is obvious that some factors are more important than others and these factors will be separately discussed here.

#### A. Flight activity and temperature

There is no doubt that the temperature is an important, -perhaps the most important weather factor governing the flight activity of noctuids. The temperature is of fundamental importance to the metabolism of insects and consequently to the internal processes underlying locomotory activity. The temperature during the activity period has been regarded as very important by many authors studying the flight activity of noctuids. Hosney (1953) found that in open terrain the mean night temperature is the most important thermal





factor. Sylvén (1958) observed that the catch tended to be low or non-existent when the night temperature was below  $10 - 11^{\circ}\text{C}$ . Larsen (1943) states that every species has an optimum temperature where it is most active and a threshold temperature below which its activity ceases. The last-named temperature is lower for species flying in autumn than for summer species. She also states that the nearer the minimum demand for activity the temperature comes the stronger is its influence on the activity. When the temperature in summer falls to  $12 - 13^{\circ}\text{C}$  it becomes what she calls a master factor. Williams (1961) found that also the temperature (and precipitation) during the months before the flight period in a species, has a great influence on the size of the actual population.

In the present study, the mean night temperature has proved to be a very important factor. Due to the great number of significant partial regressions on the mean night temperature (table 10) and to the strength of the partial regressions on this factor (table 11) it seems to have had the strongest influence of all weather factors tested. It is also rather probable that the influence of a low mean night temperature is stronger than that of a high one. This assumption is based on the following observations:

In comparing the corresponding months in the two years, the month in which the mean night temperature diverged most from the corresponding 30 years mean day and night temperature for the area (excluding September and October) was that which showed the strongest partial regression on the mean night temperature (table 11).

Months with relatively low mean night temperatures show the strongest positive partial regression on this factor (May 1968, August 1968, July 1968). This applies particularly to July 1968, the only month with a day and night temperature well below the normal for the month.

In the 8 factors calculation months with relatively high mean night temperatures show either an insignificant regression or a significant negative regression (June 1968, July 1969, September 1969). The most significant negative regression was obtained in June 1968, a month with a very high mean night temperature compared to the corresponding 30-years mean day and night temperature.

A temperature fall during the night causes a stronger decrease in the catch if the temperature is already low than if it is high (fig. 48). During months with low mean night temperatures there is a good correlation between the hourly catch and the hourly temperature, while during months with high night temperatures significant correlations between catch and temperature are visible only during the last hours of the night (fig. 47).

As the night temperature during the summer months is high, the consequence of the last observation is that during the summer months, when most of the



noctuids are caught, the temperature seems to have a small influence on the diel distribution of catch, provided it is not very low. In months with very high night temperatures, as in June 1968 and July 1969, the correlation between catch and temperature is significant except for the last hours of the night when the temperature is lowest (fig. 47). Later in the year however, when the monthly mean night temperature becomes successively lower the influence of the night temperature increases. In September of both year the correlation between catch and temperature is significantly positive almost throughout the night. Consequently, in autumn, the night temperature should be regarded the most important factor governing the monthly diel distribution of catch.

It should be observed that September 1969, although it had a higher average night temperature than July 1968 shows a much better correlation to the catch than does July 1968. Thus it seems that the stronger correlation between catch and temperature in September 1969 is not entirely due to the low temperature. It is possible that the reason for this difference between July and September is that light, another important factor governing the diel distribution of catch, has a strong influence in July, while this factor is less important in September.

Not only the night temperature but also the temperature during the preceding day may affect the catch. In the analysis on the material from Bunkeflo, both positive and negative significant regressions were found on the mean day temperature. Hosney (1953) found that a high maximum day temperature during some summer months seemed to have had a negative influence on the catch. In the present study, significant negative regressions on high maximum day temperatures were found in some months (table 13B). It is a well known fact that low temperatures may cause the activity to cease, but it is more difficult to explain why high day temperatures have a negative effect when the prevailing night temperature seems favourable for flight activity. It was also observed during the wind velocity experiments that the moths tested after days with very high temperatures showed a higher intensity of flight than moths during periods with more moderate day temperatures. Consequently, it is hardly probable that high day temperatures are negative to flight activity of moths present in the area. It has been shown that the lifetime after capture of moths is shorter when the temperature is high (fig. 89), and that high maximum day temperature during dry periods may have a lethal effect on moths kept for observation of the death-rate (fig. 90). The reason for this is a desiccation effect. Consequently the maximum day temperature does not affect the flight activity of noctuids in a negative way but decreases the number of moths available for catch.





During months with low average temperatures the number of significant regressions on weather factors, not only on temperature factors, and the number of significant correlations between weather factors and catch is much higher than during months with high average temperatures. This is well illustrated in July of both years (fig. 32). Consequently, it is possible that the temperature not only has a direct effect but also is of importance for the influence that other factors have on the catch.

#### B. Flight activity and wind.

Of the weather factors investigated, the mean night wind velocity seems to have been the second most important factor. A number of significant negative regressions on this factor are apparent in the analyses (table 15). The wind during the night, like the mean night temperature, has also been regarded as very important by many earlier students concerned with the flight activity of noctuids. Larsen (1943) suggested that the night wind in open terrain is often the dominant factor. Hosney (1953) found a significant negative influence of the mean night wind velocity on flight activity in open terrain. This negative influence seemed to be somewhat stronger when the general average temperature of the month was low. In the present study too, there were some indications of this. Thus, in July 1968, a rather strong significant negative regression was found on the night wind despite the fact that the average night wind velocity was as low as 1.9 m/s. In July 1969, no significant regression was found on a mean night wind velocity of 2.3 m/s (table 15). As can be seen from table 8, the average night temperature in July 1969 was high, while in July 1968 it was low.

This indicates that the wind has a cooling effect on noctuids. If the temperature is already low and near the minimum demand for activity, a decrease in body temperature caused by wind will have a stronger negative effect than if the temperature is moderate. As a consequence of this, winds in connection with low night temperatures have a stronger negative effect.

A number of significant negative regressions on strong mean night wind velocities were also found in the analyses (table 16). This indicates that high wind velocities have a stronger influence than could have been expected if the influence of the night wind was linear. Harling (1968) found that the wind force had an inhibiting effect on the flight activity of noctuids when the wind velocity exceeded 3 on Beaufort's scale (3.4-5.4 m/s). This is confirmed by the wind velocity experiments performed at Bunkeflo (fig. 58). In these it was also observed that small species were most sensitive to wind. Thus it is very probable that the effect of strong winds is partly mechanical. This may explain why the influence of high wind velocities seems to be



more independent of the prevailing night temperature.

It is possible that the wind during the night may sometimes have an indirect positive effect. During some months it was found that the wind was significantly positively correlated to the night temperature and negatively correlated to the temperature range of the night (July 1969, August 1969). This indicates that the wind during clear nights with a strong negative radiation may prevent the temperature from falling below the minimum demand for activity.

High day wind velocities seem to have a negative influence on the number of moths available to catch by increasing the evapotranspiration caused by high maximum temperatures and high vapor pressure deficits.

### C. Flight activity and precipitation.

Also this factor has been regarded as important by earlier authors. Larsen (1943) states that rainfall often acts as a master factor and that it often inhibites the activity even if other factors, such as temperature, are favourable. Harling (1968) found that rainfall during daytime appears to be associated with low catch on the following night.

In the present study, rainfall has been found to have both positive and negative effects on the flight activity of noctuids. Rainfall during the day before the flight has also proved to have some influence. It seems that the amount of rain is less important than the temperature and wind conditions at the same time. Warm rains normally seem to have a positive, cold rains a negative effect (table 19, fig. 35).

The negative effect of cold rains may be due to their influence on body temperature. The evaporation into the surrounding air is increased, which results in falling temperature in the flight area. This process takes some time and the effect on the body temperature is delayed. It is a common observation that flight activity during cold showers does not cease immediately, but after the rain has stopped, flight may cease completely. It is quite probable that the wind has a strengthening effect on this process. The strongest negative influence of cold rain was found during nights with high wind velocities (table 19 C).

The positive effect of warm rains may be due to the influence rainfall has on the internal water-balance of the moth. During dry warm months the maintenance of a suitable water-balance becomes a serious problem. The importance of access to water was also demonstrated in one of the experiments presented earlier. In table 19 it can be seen that the strongest positive influence of rain was found in the driest of the months investigated as regards influence of rain, i.e. June 1969. Particularly rainfall during the day, when the temperature was at its highest, had a strong positive effect. In the analysis, a significant positive regression was found on high amounts of rain during





the night in September 1969, the driest month of all during the two years. In this month, which also had the highest temperature compared to the normal, only 18 mm rain fell against normally 50 mm (table 8). Thus rainfall during warm dry months seems to have a positive effect.

Even very small amounts of rain in connection with warm dry periods may give rise to strong increases in the catch. In June 1969 the temperature started rising on the 9th but the corresponding rise in catch did not occur until the night of the 17th, when 0.5 mm rain fell (fig.13, fig.40).

The influence of the monthly amount of rain on the monthly catch seems to be dependent on the monthly average day and night temperature. In July 1968, the very high precipitation in connection with low temperatures seems to have had a strong negative effect (table 19). The catch in July 1968 was also much lower than in July 1969 (table 2). In August 1969, however, when high precipitation was also registered, rainfall during the night had a positive effect. In this month, too, the highest mean night temperature of all months investigated was recorded. In the analysis a significant positive regression on rainfall during the night was found. Thus, during months with high temperatures a high monthly rainfall seems to have a positive effect. Abundant precipitation during warm months seems to prevent desiccation of the moths, which otherwise would be the result of high maximum day temperatures in connection with high vapor pressure deficits. If the monthly precipitation is very low, as in June 1969, the desiccation of the moths reduces the number available to catch. This is indicated by the strong negative regression on the day vapor pressure deficit in June 1969 (table 14), and also by the observations on the death-rate of newly captured moths in the same month (fig. 90).

The negative effect of cold rains on the flight activity is evidently direct. The positive effect of warm rains, however, is probable to a great part an effect on the number of moths available. There is no doubt, however, that warm rains may also have a direct positive effect on flight activity. It has, frequently been observed that flight activity suddenly increases when warm rains start. During dry periods with high day temperatures even heavy rains in connection with thunderstorms do not prevent lively flight activity.

#### D. Flight activity and light.

Few authors have paid attention to light as a factor affecting the catch of night-flying Lepidoptera and the nocturnal distribution of their flight activity. Larsen (1943), during a period of 12 days in 1939, observed the influence of light on the nocturnal distribution of catch. Sylvén (1958), in his paper on fruit leaf tortricids, says that cloudiness might have had a positive effect on the catch. However, he also says that this might have been due to the effect cloudy weather has on night temperature.



The factor inducing the flight start of noctuids at Bunkeflo was light or decreasing light. It cannot be excluded, however, that the diel temperature range may also have had at least a small influence. Scott (1936) found that a temperature drop may have a phase-setting effect on the diel activity rhythm of Anagasta kuhniella, and this was confirmed by Moriarty (1959). At Bunkeflo, the impulse to start flight, caused by the light, was so strong that even hard weather conditions could not prevent it.

It is also shown that the night light in summer may have a strong influence on the distribution of nocturnal flight activity. This conclusion is based on the following observations:

1. The curves for the nocturnal distribution of catch in June, July and August of both years, have a shape that could hardly have been produced by any other factor than light (fig. 25).
2. The shape of the curves for different summer months also reflects well the converted light curve for the actual month (fig. 84). Thus, in June, when only a small part of the night is really dark, most of the catch occurs around midnight. In July, and especially in August, when the really dark period is longer, the catch is more evenly distributed over the dark hours, even though the highest catch here also occurs around midnight. In September and particularly October, when the night is long there is a decline in the catch curve corresponding with the fall in the temperature curve (fig. 25).
3. The curve for the yearly nocturnal distribution of catch is almost exactly the same in 1969 as in 1968 (fig. 23). The same applies to the curves for the sexes (fig. 24). The only factor capable of giving such a symmetric curve as that in fig. 23 is light.

Thus, the nocturnal distribution of catch in summer, would seem to be mainly determined by light. However, a close study of fig. 23 may give rise to certain objections against this assumption.

As is clear from the figure, the catch is higher between 24.00 and 01.00 than between 23.00 and 24.00. A still greater difference is found between 22.00-23.00 and 01.00-02.00. This asymmetry contradicts the assumption that light is the only factor determining the nocturnal distribution of catch. On the other hand, if the temperature had been the most important factor, the catch later in the night (01.00-02.00) would have been smaller than the catch 22.00-23.00, which is not the case. The reason for the asymmetry is simply that the automatic light trap was adjusted to Swedish normal time and not to the local astronomic time. Consequently, midnight in the catching area comes later than indicated in fig. 23. If the catch is adjusted to the real local time, the curves become symmetric (fig. 84). Regarding the shape of the light curve in fig. 84, it is also evident that the





difference between local time and Swedish normal time as to light intensity is much stronger in the hours 22.00 - 23.00 and 01.00 - 02.00 than between 23.00 - 24.00 and 24.00 - 01.00. Accordingly, in fig. 23, there must be a stronger asymmetry of catch between the two hours early and late in the night than between the two hours before and after midnight. That the mistake in the timing of the trap also gave rise to an asymmetry around midnight indicates that even such small changes in light as those occurring between 23.00 - 24.00 and 24.00 - 01.00 are of importance to the distribution of catch, and that noctuids are very sensible to even low light intensities.

In the actograph experiments on the influence of normal night light in June, it was found that the moths exposed to light in some cases showed a lower flight activity than the control group, in some cases not. In the experiment on June 21st, the brightest night of the year, the moths exposed to the light were just as active as those not exposed (fig. 74). In the flight start observations, it was found that the moths started to fly at a higher light intensity if the temperature was high (fig. 68). It is possible that the very high night temperature prevailing during the night of June 21st made the moths less sensible to light. Temperature influence on the phototactic reactions of insects has also been found by Perttunen (1960).

Moonlight as a factor affecting the flight activity of noctuids has been investigated by several workers. Williams (1936) found that moonlight had a negative effect on the catch. This result was confirmed by Hosney (1953). Sylvén (1958), on the other hand, found no evidence of a lunar effect during his investigations.

The direct observations on the influence of moonlight on moths kept in actographs at Bunkeflo in 1970 strongly indicate that moonlight has a depressing effect on flight activity (figs. 75 to 79).

From these results it is also obvious that cloudiness has a strong influence on the nocturnal distribution of catch by affecting the light conditions in the area. In the moonlight experiment, August 1970, it was found that cloudiness caused a sudden strong dimming of light, which gave rise to increased activity by the moths exposed to the moonlight. A study of the primary material on the hourly catches shows that there were very great differences between adjacent hours of the same night, differences not explainable either by the influence of weather factors or by the normal trend of night light. It is rather probable that these sudden changes in catch were due to changes in cloudiness above the area. Such unexplainable changes were not found later in the year when the influence of light was weaker. However, during full moon periods even in autumn, cloudiness may be of importance.

The curves for distribution of catch of males and females during the night



are quite different. During the summer the females sometimes show a bimodal activity curve (fig. 25) while the males are most frequently captured around midnight. The slight asymmetry in the curves of hourly catch of females, the second peak weaker than the first, is probably due to the lower temperature later in the night. A bimodal distribution of the activity of females was also found in the actograph experiments (fig. 80). The observations on the diel distribution of egg-laying activity by means of the egg-laying recording apparatus show that in summer this activity occurs in the early and late parts of the night while it is very low around midnight (fig. 86). A bimodal rhythm in the nocturnal ovipositional behaviour has also been found in other insects (Harwood, 1965). It is very possible that in noctuids there are sex differences in the response to light.

The actograph experiments under artificial light conditions (figs. 81, 82) indicate that the diel distribution of activity of noctuids is photoperiodically initiated. The circadian rhythm in total darkness in the experiments at Bunkeflo seems to have been phase-set by the last twilight period to which the moths had been exposed. In the artificial moonlight experiments (fig. 83) it was shown that noctuids respond to artificial light of the same intensity as moonlight (0.17 lux).

#### E. Influence of weather factors on the number of moths available to catch.

The death-rate of noctuids is temperature-dependent (figs. 89, 90). This applies to both spring and summer species and probably, although this has not been investigated, also to autumn species. However, as the average temperature in summer is normally higher than in spring, the lifetime of summer species is shorter than that of spring species (fig. 89). It was observed in the flight start observations that individuals belonging to spring species could remain inactive in their shelters for several days if weather conditions were bad. This temperature-regulated capacity of spring species to survive long periods of inactivity must be regarded as a great advantage. If their lifetime had been short independently of temperature, as is hypothetically illustrated in fig. 97 A, they would not be able to survive in their shelters. The prolonged lifetime at low temperatures allows them to wait for an opportunity to fulfil their reproductive duties under more favourable conditions. (fig. 97A).

In order to survive, noctuids are dependent on the supply of water. This influences the time of inactive survival. However, as the periods of inactivity in spring normally coincide with periods of low temperature with correspondingly low basal metabolism, their need for water and food during these periods is small and their ability to survive great.

It is quite possible that, when the temperature rises, not only the death-





rate increases but also the number of moths hatching (fig. 99). If so, the only result of the higher temperature in summer would be an accelerated turnover of individuals in summer species compared with the spring species.

During periods with very high maximum day temperatures, the death-rate was found to be very high (fig. 90). As high vapor pressure deficits and high day wind velocities also proved to have a negative effect it is probable that this higher death-rate was due to desiccation of the animals caused by high evapotranspiration. The results of the earlier analyses also confirm that high maximum day temperatures and high day vapor pressure deficits may have a negative effect on the catch, particularly if the monthly precipitation is low. As a result of this, during warm dry periods the number of moths available to catch decreases. It should be observed, however, that this is an effect on the number of individuals present in the area and not on the activity of the moths surviving the unfavourable conditions. On the contrary, it is rather probable that the need for water during these periods becomes what Larsen calls a master factor. This was also indicated by the observations on the intensity of flight during the wind velocity experiments and by the great increases in catch in connection with rainfall during warm dry periods.

#### F. The co-operation of environmental factors.

There is no doubt that a very complex co-operation between environmental factors exists, and that the influence of a single factor is strongly dependent on the influence of other factors.

It was found in the analyses that when the average monthly temperature was low, factors other than temperature also had a stronger influence. This was indicated by the variance explainable by weather factors being higher during months with low than during months with high temperatures (fig. 33). If the temperature was very low, as in July 1968; the explained variance was very high (over 90 per cent); if the temperature was high, as in July 1969, it was very low (table 17, fig. 33). Thus it seems that the temperature is the factor with the strongest influence on the effect that other weather factors have on the catch.

It has been pointed out earlier, the temperature has a fundamental influence on the metabolic processes underlying locomotor activity of insects. It is also a well known fact that if the temperature is very low, no activity is possible. If the body temperature of the moths is already low and near the minimum demand for activity, every other factor causing the temperature to fall still more will have a strong influence on flight activity. Thus wind and / or rainfall had a stronger influence if the temperature was low. Low temperatures, strong winds and cold rains are characteristic of low pressure



situations in the area during the summer. The catches during such periods were therefore small (fig. 36). It was also found that high day temperatures in connection with low monthly precipitation had a negative effect on the catch by reducing the number of moths flying in the area. Warm dry weather is characteristic of high pressure situations in the area and during such periods the catch was also reduced (fig. 36).

It seems that there are two principal reasons why the catch may be low.

1. Low flight activity due to low temperatures, high precipitation or high wind velocities (low pressure situations). A rise in the temperature and / or reduced precipitation, and a lower wind velocity then increases the catch. A typical month with this pattern was July 1968.
2. Reduced number of moths in the area due to high temperatures in connection with high vapor pressure deficits caused by low precipitation and / or high wind velocities. A decrease in temperature and / or higher precipitation, as well as a decrease in wind velocity, then would increase the catch. A typical month with this pattern was June 1969 (high air pressure situation).

In the first case the body temperature is too low for activity and in the second the desiccation, due to high evapotranspiration, has a lethal effect through the water balance of the moths.

Thus it seems that the ideal conditions for maximum catch are moderate temperature, moderate precipitation, and low wind velocity (normal air pressure situation, fig. 36). In other words, the highest catches are obtained when the monthly average values for the three weather factors mentioned approach the corresponding monthly long-time average values (the 30-year values in the tables), to which the moths are probably adapted by natural selection.

Two important conclusions may be drawn from the above statement.

1. No generally valid ideal temperature or amount of precipitation exist. The ideal conditions for every locality and month are the local long-time monthly average values. Thus both the time aspect and the space aspect must be considered.
2. No conclusions as to the effect of a certain factor can be drawn from its diel or monthly average value unless at the same time the corresponding values for other factors are known and considered.

It is also evident that if a factor is negative this may be compensated for by other factors. Thus, in July 1969 the temperature was very high. This, however, was compensated for by high precipitation, the conditions became favourable and a high monthly catch was obtained.

The more ideal the situation, as far as weather factors are concerned for a high catch the less influence single factors have on the change in catch. Thus, in months with favourable weather conditions and high monthly catches, the





variance explainable by weather factors is low (July 1969).

During the summer months, provided that the night temperature is not extremely low, light seems to be the most important factor governing the nocturnal distribution of flight activity in noctuids. Under such conditions the night temperatures only seem to have a modifying influence. Later in the year, however, the influence of the night temperature increases, at the same time as the influence of light decreases. In autumn, the night temperature should be regarded as the most important factor. However, during full moon periods even then, light may temporarily play the dominating role.

The factor (or factors) that in a certain situation has the strongest influence on the catch of noctuids is the one nearest the minimum demand for activity and survival. As far as activity is concerned this "master" factor in summer is normally light, while in spring and autumn it is normally temperature. During individual nights it may also be wind or precipitation. Light has a phase-setting effect on the diel activity all the year round because it induces start of flight.

The results of the investigations at Bunkeflo thus in all essentials support the theory, presented by Ellinor Bro Larsen already in 1943, on the influence of environmental factors on the flight activity of noctuids.

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# **APPENDIX I**

## **TABLES**





Table 1

## TOTAL CATCH, LEPIDOPTERA, 1968, 1969.

| Month                            | Year | Noctuidae    | Geometridae | Bombyces   | Sphingidae | Microlepidoptera | Other fam. groups | All Lepidoptera | % of total yearly catch |
|----------------------------------|------|--------------|-------------|------------|------------|------------------|-------------------|-----------------|-------------------------|
| April                            | 1968 | 484          | 2           | 2          | 0          | 45               | 0                 | 533             | 1.4                     |
|                                  | 1969 | 88           | 6           | 0          | 0          | 1                | 0                 | 95              | 0.2                     |
| May                              | 1968 | 164          | 26          | 7          | 2          | 49               | 6                 | 254             | 0.6                     |
|                                  | 1969 | 190          | 19          | 8          | 1          | 18               | 1                 | 237             | 0.5                     |
| June                             | 1968 | 6858         | 364         | 43         | 39         | 1328             | 188               | 8820            | 22.6                    |
|                                  | 1969 | 4594         | 473         | 53         | 60         | 998              | 127               | 6305            | 14.4                    |
| July                             | 1968 | 8820         | 793         | 27         | 22         | 5417             | 31                | 15110           | 38.5                    |
|                                  | 1969 | 11515        | 1250        | 49         | 28         | 8936             | 38                | 21816           | 49.8                    |
| Aug.                             | 1968 | 6987         | 1018        | 25         | 1          | 3640             | 45                | 11716           | 29.9                    |
|                                  | 1969 | 5895         | 2083        | 27         | 0          | 5262             | 46                | 13313           | 30.4                    |
| Sept.                            | 1968 | 1807         | 58          | 0          | 0          | 493              | 1                 | 2359            | 6.0                     |
|                                  | 1969 | 1199         | 55          | 0          | 0          | 312              | 0                 | 1566            | 3.6                     |
| Okt.                             | 1968 | 314          | 10          | 5          | 0          | 28               | 0                 | 357             | 0.9                     |
|                                  | 1969 | 417          | 3           | 7          | 0          | 41               | 0                 | 468             | 1.1                     |
| Nov.                             | 1968 | 29           | 7           | 10         | 0          | 3                | 0                 | 49              | 0.1                     |
|                                  | 1969 | 0            | 0           | 6          | 0          | 0                | 0                 | 6               | 0.0                     |
| Sum                              | 1968 | 25463        | 2278        | 119        | 64         | 11003            | 271               | 39198           | 100.0                   |
|                                  | 1969 | 23898        | 3889        | 150        | 89         | 15568            | 212               | 43806           | 100.0                   |
| Total +<br>sum: 1968<br>1969     |      | 49361        | 6167        | 269        | 153        | 26571            | 483               | 83004           |                         |
| % of 1968<br>total<br>catch 1969 |      | 65.0<br>54,6 | 5,8<br>8,9  | 0,3<br>0,3 | 0.1<br>0,2 | 28.1<br>35,5     | 0.7<br>0,5        | 100.0<br>100,0  |                         |
| change<br>from 1968<br>to 1969 % |      | -6,1         | +70.7       | +26.1      | +39.1      | +41.5            | +21.8             | +11.8           |                         |

April 1968 = 21.4-30.4

April 1969 = 8.4-30.4



Table 2

## FAM. NOCTUIDAE: CATCH 1968, 1969

| Month | Year             | no of<br>males | no of<br>females | %<br>females | monthly<br>catch | % of<br>yearly<br>catch | % of<br>total<br>catch of<br>females | % of<br>total<br>catch of<br>males |
|-------|------------------|----------------|------------------|--------------|------------------|-------------------------|--------------------------------------|------------------------------------|
| April | 1968             | 413            | 71               | 14.6         | 484              | 1.9                     | 1.2                                  | 2.1                                |
|       | 1969             | 77             | 11               | 12.5         | 88               | 0.4                     | 0.2                                  | 0.4                                |
| May   | 1968             | 134            | 30               | 18.3         | 164              | 0.7                     | 0.5                                  | 0.7                                |
|       | 1969             | 140            | 50               | 26.3         | 190              | 0.8                     | 0.9                                  | 0.8                                |
| June  | 1968             | 5586           | 1272             | 18.5         | 6858             | 26.9                    | 21.7                                 | 28.5                               |
|       | 1969             | 3705           | 889              | 19.4         | 4594             | 19.2                    | 16.0                                 | 20.2                               |
| July  | 1968             | 7101           | 1719             | 19.5         | 8820             | 34.6                    | 29.3                                 | 36.2                               |
|       | 1969             | 9028           | 2487             | 21.6         | 11515            | 48.2                    | 44.7                                 | 49.3                               |
| Aug.  | 1968             | 4862           | 2125             | 30.4         | 6987             | 27.5                    | 36.4                                 | 24.8                               |
|       | 1969             | 4323           | 1572             | 26.7         | 5895             | 24.7                    | 28.2                                 | 23.6                               |
| Sept. | 1968             | 1296           | 511              | 28.3         | 1807             | 7.1                     | 8.7                                  | 6.6                                |
|       | 1969             | 797            | 402              | 33.5         | 1199             | 5.0                     | 7.2                                  | 4.3                                |
| Okt.  | 1968             | 196            | 118              | 37.6         | 314              | 1.2                     | 2.0                                  | 1.0                                |
|       | 1969             | 259            | 158              | 37.9         | 417              | 1.7                     | 2.8                                  | 1.4                                |
| Nov.  | 1968             | 18             | 11               | 37.9         | 29               | 0.1                     | 0.2                                  | 0.1                                |
|       | 1969             | 0              | 0                | 0.0          | 0                | 0.0                     | 0.0                                  | 0.0                                |
| Sum   | 1968             | 19606          | 5857             | 23.0         | 25463            | 100.0                   | 100.0                                | 100.0                              |
| Sum   | 1969             | 18329          | 5569             | 23.3         | 23898            | 100.0                   | 100.0                                | 100.0                              |
| Sum   | + 1968<br>+ 1969 | 37935          | 11426            | 23.2         | 49361            |                         |                                      |                                    |

April 1968 = 21.4-30.4

April 1969 = 8.4-30.4





Table 3. NUMBER OF INDIVIDUALS PER SPECIES

| No.of moths | No.of species 1968 | No.of species 1969 |
|-------------|--------------------|--------------------|
| 1           | 31                 | 31                 |
| 2-9         | 39                 | 45                 |
| 10-49       | 39                 | 37                 |
| 50-99       | 10                 | 12                 |
| 100-199     | 18                 | 13                 |
| 200-499     | 15                 | 11                 |
| 500-999     | 5                  | 8                  |
| 1000-1999   | 3                  | 2                  |
| 2000-2999   | 1                  | 2                  |
| 3000-3999   | 2                  | 0                  |
| 4000-       | 0                  | 1                  |

163

162

Appearing only in 1968 = 19 species

Appearing only in 1969 = 19 species

Number of species 1968 +1969 = 182

Table 4. MEAN DAILY NUMBER OF SPECIES IN DIFFERENT MONTHS

|      | April | May | June | July | August | September | October |
|------|-------|-----|------|------|--------|-----------|---------|
| 1968 | 5.9   | 2.3 | 24.3 | 39.5 | 25.3   | 9.6       | 0.3     |
| 1969 | 1.0   | 2.5 | 20.1 | 40.1 | 25.3   | 9.2       | 2.3     |



| Table 5 | Specie          | 1968        |               |           | 1969        |                   |             | 1968 and 1969 |           |              |                  |
|---------|-----------------|-------------|---------------|-----------|-------------|-------------------|-------------|---------------|-----------|--------------|------------------|
|         |                 | No.of males | No.of females | % females | No.of moths | % of yearly catch | No.of males | No.of females | % females | No of. moths | % of total catch |
| 1.      | A.exclamationis | 2376        | 665           | 21.9      | 3041        | 11.9              | 3879        | 1038          | 21.1      | 4917         | 20.6             |
| 2.      | R.c-nigrum      | 1665        | 440           | 20.9      | 2105        | 8.3               | 1958        | 818           | 29.5      | 2776         | 11.6             |
| 3.      | P.Gamma         | 2170        | 1439          | 39.9      | 3609        | 14.2              | 749         | 415           | 35.7      | 1164         | 4.9              |
| 4.      | R.rubi          | 964         | 334           | 25.7      | 1298        | 5.1               | 1512        | 659           | 30.4      | 2171         | 9.2              |
| 5.      | E.morpheus      | 1091        | 169           | 13.4      | 1260        | 4.8               | 791         | 219           | 21.7      | 1010         | 4.2              |
| 6.      | T.pronuba       | 970         | 194           | 16.7      | 1164        | 4.6               | 521         | 111           | 17.6      | 632          | 2.6              |
| 7.      | A.segetum       | 739         | 167           | 18.4      | 906         | 3.6               | 558         | 102           | 15.5      | 660          | 2.8              |
| 8.      | H.alsines       | 721         | 111           | 13.3      | 832         | 3.3               | 596         | 127           | 17.6      | 723          | 3.0              |
| 9.      | P.monoglyph     | 695         | 37            | 5.1       | 732         | 2.9               | 507         | 48            | 8.6       | 555          | 2.3              |
| 10.     | P.strigilis     | 413         | 42            | 9.2       | 455         | 1.8               | 416         | 108           | 20.6      | 524          | 2.2              |
| 11.     | S.pallens       | 158         | 456           | 74.3      | 614         | 2.4               | 89          | 250           | 73.7      | 339          | 1.4              |
| 12.     | H.blanda        | 446         | 93            | 17.3      | 539         | 2.1               | 208         | 83            | 28.5      | 291          | 1.2              |
|         | Sum             | 12408       | 4147          | 25.0      | 16555       | 65.0              | 11784       | 3978          | 25.2      | 15762        | 66.0             |
|         |                 |             |               |           |             |                   | 6255        | 1703          | 21.4      | 7958         | 16.1             |
|         |                 |             |               |           |             |                   | 3623        | 1258          | 25.8      | 4881         | 9.9              |
|         |                 |             |               |           |             |                   | 2919        | 1854          | 38.8      | 4773         | 9.7              |
|         |                 |             |               |           |             |                   | 2476        | 993           | 28.6      | 3469         | 7.0              |
|         |                 |             |               |           |             |                   | 1882        | 388           | 17.1      | 2270         | 4.6              |
|         |                 |             |               |           |             |                   | 1491        | 305           | 17.0      | 1796         | 3.6              |
|         |                 |             |               |           |             |                   | 1297        | 269           | 17.2      | 1566         | 3.2              |
|         |                 |             |               |           |             |                   | 1317        | 238           | 15.4      | 1555         | 3.2              |
|         |                 |             |               |           |             |                   | 1202        | 85            | 6.6       | 1287         | 2.6              |
|         |                 |             |               |           |             |                   | 829         | 150           | 15.3      | 979          | 2.0              |
|         |                 |             |               |           |             |                   | 247         | 706           | 74.1      | 953          | 1.9              |
|         |                 |             |               |           |             |                   | 654         | 176           | 21.2      | 830          | 1.7              |
|         |                 |             |               |           |             |                   | 24192       | 8125          | 25.1      | 32317        | 65.5             |





Table 6. AVERAGE NUMBER OF FEMALES IN DIFFERENT ABUNDANCE GROUPS OF SPECIES

| 1968       |         |        |         | 1969    |        |         | total  |         |
|------------|---------|--------|---------|---------|--------|---------|--------|---------|
| species    | no.of   | no.of  | %       | no.of   | no.of  | %       | no.of  | %       |
| sizegroups | species | indiv. | females | species | indiv. | females | indiv. | females |
| 1-4        | 53      | 104    | 25.0    | 54      | 103    | 29.1    | 207    | 25.7    |
| 5-9        | 13      | 82     | 30.5    | 21      | 136    | 33.8    | 218    | 32.5    |
| 10-19      | 20      | 277    | 30.0    | 20      | 273    | 33.1    | 550    | 25.6    |
| 20-49      | 19      | 621    | 16.3    | 17      | 510    | 24.7    | 1131   | 20.1    |
| 50-99      | 10      | 710    | 15.4    | 13      | 999    | 21.4    | 1709   | 18.8    |
| 100-199    | 18      | 2784   | 21.4    | 13      | 1626   | 18.2    | 4410   | 20.2    |
| 200-399    | 14      | 4041   | 17.3    | 9       | 2465   | 23.9    | 6557   | 19.7    |
| 400-799    | 4       | 2394   | 26.2    | 10      | 5596   | 18.5    | 7990   | 25.1    |
| 800-1599   | 5       | 5460   | 17.9    | 3       | 4950   | 29.3    | 10410  | 23.3    |
| 1600-3199  | 2       | 5146   | 21.5    | 1       | 2171   | 30.4    | 7317   | 24.1    |
| 3200-      | 1       | 3609   | 39.9    | 1       | 4917   | 21.1    | 8526   | 29.1    |
|            | 163     | 25224  | 23.0    | 162     | 23746  | 23.3    | 48970  | 23.2    |



Table 7

NUMBER OF NOCTUIDS PER HOUR, 1968

| Hour                   |            | April | May | June | July | Aug. | Sept. | Okt. | Nov. | Sum   | % of<br>total<br>catch | %<br>females<br>/hour |
|------------------------|------------|-------|-----|------|------|------|-------|------|------|-------|------------------------|-----------------------|
| 18-19                  | males      | 0     | 0   | 0    | 0    | 0    | 13    | 33   | 5    | 51    | 0.3                    |                       |
|                        | females    | 0     | 0   | 0    | 0    | 3    | 17    | 33   | 6    | 59    | 0.1                    | 53.6                  |
|                        | sum        | 0     | 0   | 0    | 0    | 3    | 30    | 66   | 11   | 110   | 0.4                    |                       |
| 19-20                  | males      | 1     | 0   | 0    | 0    | 6    | 61    | 34   | 6    | 108   | 0.6                    |                       |
|                        | females    | 0     | 0   | 0    | 0    | 15   | 41    | 16   | 0    | 72    | 1.2                    | 40.0                  |
|                        | sum        | 1     | 0   | 0    | 0    | 21   | 103   | 50   | 6    | 180   | 0.7                    |                       |
| 20-21                  | males      | 11    | 10  | 0    | 6    | 269  | 102   | 15   | 4    | 417   | 2.1                    |                       |
|                        | females    | 7     | 0   | 0    | 3    | 203  | 65    | 17   | 3    | 298   | 5.1                    | 41.7                  |
|                        | sum        | 18    | 10  | 0    | 9    | 472  | 167   | 32   | 7    | 715   | 2.8                    |                       |
| 21-22                  | males      | 33    | 4   | 85   | 238  | 733  | 159   | 17   | 1    | 1270  | 6.5                    |                       |
|                        | females    | 13    | 0   | 54   | 131  | 484  | 73    | 8    | 0    | 763   | 13.0                   | 37.5                  |
|                        | sum        | 46    | 4   | 139  | 369  | 1217 | 232   | 25   | 1    | 2033  | 8.0                    |                       |
| 22-23                  | males      | 35    | 25  | 711  | 985  | 797  | 169   | 11   | 0    | 2733  | 13.9                   |                       |
|                        | females    | 19    | 8   | 307  | 388  | 426  | 46    | 5    | 1    | 1200  | 20.5                   | 30.5                  |
|                        | sum        | 54    | 33  | 1018 | 1373 | 1223 | 215   | 16   | 1    | 3933  | 15.4                   |                       |
| 23-24                  | males      | 81    | 30  | 1547 | 2081 | 867  | 199   | 7    | 0    | 4812  | 24.4                   |                       |
|                        | females    | 10    | 7   | 375  | 491  | 324  | 48    | 4    | 0    | 1259  | 21.5                   | 20.7                  |
|                        | sum        | 91    | 37  | 1922 | 2572 | 1191 | 247   | 11   | 0    | 6071  | 23.8                   |                       |
| 24-01                  | males      | 119   | 33  | 1738 | 2182 | 941  | 228   | 13   | 1    | 5255  | 26.8                   |                       |
|                        | females    | 7     | 6   | 250  | 339  | 227  | 65    | 7    | 1    | 902   | 15.4                   | 14.6                  |
|                        | sum        | 126   | 39  | 1988 | 2521 | 1168 | 293   | 20   | 2    | 6157  | 24.2                   |                       |
| 01-02                  | males      | 94    | 28  | 1266 | 1335 | 723  | 147   | 11   | 0    | 3604  | 18.4                   |                       |
|                        | females    | 11    | 8   | 211  | 267  | 231  | 61    | 7    | 0    | 796   | 13.6                   | 18.1                  |
|                        | sum        | 105   | 36  | 1477 | 1602 | 954  | 208   | 18   | 0    | 4400  | 17.4                   |                       |
| 02-03                  | males      | 31    | 3   | 214  | 245  | 306  | 83    | 10   | 1    | 893   | 4.6                    |                       |
|                        | females    | 3     | 1   | 64   | 85   | 94   | 27    | 8    | 0    | 282   | 4.8                    | 24.0                  |
|                        | sum        | 34    | 4   | 278  | 330  | 400  | 110   | 18   | 1    | 1175  | 4.6                    |                       |
| 03-04                  | males      | 5     | 1   | 25   | 27   | 195  | 94    | 21   | 0    | 368   | 1.9                    |                       |
|                        | females    | 1     | 0   | 11   | 14   | 103  | 49    | 3    | 0    | 181   | 3.1                    | 33.0                  |
|                        | sum        | 6     | 1   | 36   | 41   | 298  | 143   | 24   | 0    | 549   | 2.2                    |                       |
| 04-05                  | males      | 3     | 0   | 0    | 2    | 25   | 36    | 8    | 0    | 74    | 0.4                    |                       |
|                        | females    | 0     | 0   | 0    | 1    | 15   | 17    | 2    | 0    | 35    | 0.6                    | 32.1                  |
|                        | sum        | 3     | 0   | 0    | 3    | 40   | 53    | 10   | 0    | 109   | 0.4                    |                       |
| 05-06                  | males      | 0     | 0   | 0    | 0    | 0    | 5     | 16   | 0    | 21    | 0.1                    |                       |
|                        | females    | 0     | 0   | 0    | 0    | 0    | 2     | 8    | 0    | 10    | 0.2                    | 32.3                  |
|                        | sum        | 0     | 0   | 0    | 0    | 0    | 7     | 24   | 0    | 31    | 0.1                    |                       |
| total<br>sum           | males      | 413   | 134 | 5586 | 7101 | 4862 | 1296  | 196  | 18   | 19606 | 100.0                  |                       |
|                        | females    | 71    | 30  | 1272 | 1719 | 2125 | 511   | 118  | 11   | 5857  | 100.0                  | 100.0                 |
|                        | both sexes | 484   | 164 | 6858 | 8820 | 6987 | 1807  | 314  | 29   | 25463 | 100.0                  |                       |
| % of<br>total<br>catch | males      | 2.1   | 0.7 | 28.5 | 36.2 | 24.8 | 6.6   | 1.0  | 0.1  | 100.0 |                        |                       |
|                        | females    | 1.2   | 0.5 | 21.7 | 29.3 | 36.4 | 8.7   | 2.0  | 0.2  | 100.0 |                        |                       |
|                        | both sexes | 1.9   | 0.7 | 26.9 | 34.6 | 27.5 | 7.1   | 1.2  | 0.1  | 100.0 |                        |                       |





Table 7 (cont'd)

NUMBER OF NOCTUIDS PER HOUR, 1969

| Hour                   |            | April | May | June | July  | Aug. | Sept. | Okt. | Nov. | Sum   | % of<br>total<br>catch | %<br>females<br>/hour |
|------------------------|------------|-------|-----|------|-------|------|-------|------|------|-------|------------------------|-----------------------|
| 18-19                  | males      | 0     | 0   | 0    | 0     | 0    | 0     | 50   | 0    | 50    | 0.3                    | 41.2                  |
|                        | females    | 0     | 0   | 0    | 0     | 0    | 2     | 33   | 0    | 35    | 0.6                    |                       |
|                        | sum        | 0     | 0   | 0    | 0     | 0    | 2     | 83   | 0    | 85    | 0.4                    |                       |
| 19-20                  | males      | 0     | 0   | 0    | 0     | 10   | 63    | 35   | 0    | 108   | 0.6                    | 44.6                  |
|                        | females    | 0     | 0   | 0    | 0     | 3    | 62    | 22   | 0    | 87    | 1.6                    |                       |
|                        | sum        | 0     | 0   | 0    | 0     | 13   | 125   | 57   | 0    | 195   | 0.8                    |                       |
| 20-21                  | males      | 3     | 2   | 0    | 9     | 174  | 96    | 23   | 0    | 307   | 1.7                    | 41.7                  |
|                        | females    | 0     | 1   | 0    | 1     | 135  | 61    | 22   | 0    | 220   | 4.0                    |                       |
|                        | sum        | 3     | 3   | 0    | 10    | 309  | 157   | 45   | 0    | 527   | 2.2                    |                       |
| 21-22                  | males      | 4     | 19  | 45   | 270   | 497  | 78    | 42   | 0    | 955   | 5.2                    | 37.0                  |
|                        | females    | 1     | 7   | 18   | 120   | 341  | 60    | 13   | 0    | 560   | 10.1                   |                       |
|                        | sum        | 5     | 26  | 63   | 390   | 838  | 138   | 55   | 0    | 1515  | 6.3                    |                       |
| 22-23                  | males      | 29    | 32  | 391  | 1259  | 683  | 103   | 23   | 0    | 2520  | 13.7                   | 28.6                  |
|                        | females    | 1     | 12  | 150  | 533   | 261  | 40    | 14   | 0    | 1011  | 18.2                   |                       |
|                        | sum        | 30    | 44  | 541  | 1792  | 944  | 143   | 37   | 0    | 3531  | 14.8                   |                       |
| 23-24                  | males      | 7     | 23  | 1074 | 2445  | 815  | 120   | 23   | 0    | 4507  | 24.6                   | 21.7                  |
|                        | females    | 3     | 7   | 243  | 685   | 258  | 38    | 12   | 0    | 1246  | 22.3                   |                       |
|                        | sum        | 10    | 30  | 1317 | 3130  | 1073 | 158   | 35   | 0    | 5753  | 24.1                   |                       |
| 24-01                  | males      | 15    | 30  | 1204 | 2731  | 828  | 105   | 17   | 0    | 4930  | 26.9                   | 16.5                  |
|                        | females    | 2     | 13  | 204  | 524   | 192  | 28    | 11   | 0    | 974   | 17.4                   |                       |
|                        | sum        | 17    | 43  | 1408 | 3255  | 1020 | 133   | 28   | 0    | 5904  | 24.7                   |                       |
| 01-02                  | males      | 12    | 18  | 835  | 1835  | 751  | 86    | 10   | 0    | 3547  | 19.4                   | 20.3                  |
|                        | females    | 2     | 6   | 219  | 436   | 186  | 41    | 13   | 0    | 903   | 16.2                   |                       |
|                        | sum        | 14    | 24  | 1054 | 2271  | 937  | 127   | 23   | 0    | 4450  | 18.6                   |                       |
| 02-03                  | males      | 6     | 12  | 139  | 412   | 408  | 75    | 16   | 0    | 1068  | 5.8                    | 27.3                  |
|                        | females    | 2     | 3   | 49   | 163   | 132  | 45    | 7    | 0    | 401   | 7.2                    |                       |
|                        | sum        | 8     | 15  | 188  | 575   | 540  | 120   | 23   | 0    | 1469  | 6.1                    |                       |
| 03-04                  | males      | 1     | 4   | 17   | 67    | 152  | 58    | 15   | 0    | 314   | 1.7                    | 26.6                  |
|                        | females    | 0     | 1   | 6    | 25    | 58   | 16    | 8    | 0    | 114   | 1.9                    |                       |
|                        | sum        | 1     | 5   | 23   | 92    | 210  | 74    | 23   | 0    | 428   | 1.8                    |                       |
| 04-05                  | males      | 0     | 0   | 0    | 0     | 5    | 13    | 3    | 0    | 21    | 0.1                    | 46.2                  |
|                        | females    | 0     | 0   | 0    | 0     | 6    | 9     | 3    | 0    | 18    | 0.3                    |                       |
|                        | sum        | 0     | 0   | 0    | 0     | 11   | 22    | 6    | 0    | 39    | 0.2                    |                       |
| 05-06                  | males      | 0     | 0   | 0    | 0     | 0    | 0     | 2    | 0    | 2     | 0.0                    | 0.0                   |
|                        | females    | 0     | 0   | 0    | 0     | 0    | 0     | 0    | 0    | 0     | 0.0                    |                       |
|                        | sum        | 0     | 0   | 0    | 0     | 0    | 0     | 2    | 0    | 2     | 0.0                    |                       |
| total                  | males      | 77    | 140 | 3705 | 9028  | 4323 | 797   | 259  | 0    | 18329 | 100.0                  |                       |
|                        | females    | 11    | 50  | 889  | 2487  | 1572 | 402   | 158  | 0    | 5569  | 100.0                  |                       |
|                        | both sexes | 88    | 190 | 4594 | 11515 | 5895 | 1199  | 417  | 0    | 23898 | 100.0                  |                       |
| % of<br>total<br>catch | males      | 0.4   | 0.8 | 20.2 | 49.3  | 23.6 | 4.3   | 1.4  | 0.0  | 100.0 |                        |                       |
|                        | females    | 0.2   | 0.9 | 16.0 | 44.7  | 28.2 | 7.2   | 2.8  | 0.0  | 100.0 |                        |                       |
|                        | both sexes | 0.4   | 0.8 | 19.2 | 48.2  | 24.7 | 5.0   | 1.7  | 0.0  | 100.0 | 100.0                  |                       |



Table 8

## WEATHER FACTORS, MONTHLY AVERAGE VALUES.

## 1. Temperature factors

|           | mean<br>day and<br>night<br>temp °C | mean<br>day<br>temp °C | mean<br>night<br>temp °C | max.<br>temp.<br>day °C | max.<br>temp.<br>night °C | min.<br>temp.<br>night °C | temp.<br>range<br>day °C | temp.<br>range<br>night °C | temp.<br>range<br>day and<br>night °C | max.<br>temp<br>day <sup>2</sup> | 30-<br>years<br>mean<br>day &<br>night t |
|-----------|-------------------------------------|------------------------|--------------------------|-------------------------|---------------------------|---------------------------|--------------------------|----------------------------|---------------------------------------|----------------------------------|------------------------------------------|
| 1968      |                                     |                        |                          |                         |                           |                           |                          |                            |                                       |                                  |                                          |
| May       | 9.9                                 | 10.5                   | 8.6                      | 13.0                    | 9.9                       | 7.7                       | 5.6                      | 2.2                        | 6.2                                   | 178                              | 11.0                                     |
| June      | 16.2                                | 16.8                   | 14.3                     | 20.7                    | 15.8                      | 13.2                      | 8.0                      | 2.6                        | 8.5                                   | 441                              | 15.0                                     |
| July      | 15.2                                | 16.0                   | 13.2                     | 19.0                    | 15.3                      | 12.6                      | 6.6                      | 2.7                        | 7.4                                   | 371                              | 17.3                                     |
| August    | 17.0                                | 18.1                   | 15.1                     | 22.2                    | 17.2                      | 13.7                      | 8.6                      | 3.5                        | 9.1                                   | 505                              | 16.8                                     |
| September | 14.4                                | 15.6                   | 13.0                     | 18.6                    | 15.1                      | 11.4                      | 6.9                      | 3.7                        | 7.9                                   | 366                              | 13.5                                     |
| October   | 9.7                                 | 10.8                   | 8.9                      | 12.5                    | 10.3                      | 7.9                       | 4.0                      | 2.4                        | 5.7                                   | 161                              | 9.6                                      |
| mean      | 13.7                                | 14.6                   | 12.2                     | 17.7                    | 13.9                      | 11.1                      | 6.6                      | 2.9                        | 7.5                                   | 337                              |                                          |
| 1969      |                                     |                        |                          |                         |                           |                           |                          |                            |                                       |                                  |                                          |
| May       | 10.5                                | 11.1                   | 9.1                      | 13.8                    | 10.1                      | 8.2                       | 6.1                      | 1.9                        | 6.8                                   | 199                              |                                          |
| June      | 16.1                                | 16.9                   | 13.6                     | 21.4                    | 14.9                      | 12.4                      | 9.6                      | 2.5                        | 10.2                                  | 480                              |                                          |
| July      | 18.2                                | 19.3                   | 16.2                     | 23.4                    | 18.1                      | 15.0                      | 8.8                      | 3.1                        | 9.4                                   | 560                              |                                          |
| August    | 17.9                                | 19.4                   | 15.3                     | 23.7                    | 17.8                      | 14.0                      | 10.0                     | 3.8                        | 10.7                                  | 582                              |                                          |
| September | 14.8                                | 16.0                   | 13.3                     | 19.5                    | 15.8                      | 12.0                      | 7.3                      | 3.8                        | 8.3                                   | 393                              |                                          |
| October   | 10.4                                | 11.1                   | 9.8                      | 12.1                    | 10.1                      | 8.2                       | 3.3                      | 1.9                        | 4.5                                   | 165                              |                                          |
| mean      | 14.7                                | 15.6                   | 12.9                     | 19.0                    | 14.5                      | 11.6                      | 7.5                      | 2.8                        | 8.3                                   | 397                              |                                          |

## 2. Wind factors

|  | mean<br>m/s<br>day | mean<br>m/s<br>night | max.<br>m/s<br>day | max.<br>m/s<br>night | min.<br>m/s<br>night | m/s<br>range<br>night | m/s<br>night <sup>2</sup> |
|--|--------------------|----------------------|--------------------|----------------------|----------------------|-----------------------|---------------------------|
|--|--------------------|----------------------|--------------------|----------------------|----------------------|-----------------------|---------------------------|

1968

|           |     |     |     |     |     |     |     |
|-----------|-----|-----|-----|-----|-----|-----|-----|
| May       | 2.1 | 2.6 | 3.9 | 2.7 | 1.3 | 1.4 | 5.1 |
| June      | 2.9 | 2.3 | 3.9 | 2.8 | 1.6 | 1.2 | 6.7 |
| July      | 2.7 | 1.9 | 3.8 | 2.4 | 1.3 | 1.1 | 5.3 |
| August    | 2.6 | 1.8 | 3.3 | 2.5 | 1.2 | 1.3 | 5.0 |
| September | 2.4 | 1.8 | 3.3 | 2.5 | 1.1 | 1.4 | 4.3 |
| October   | 3.1 | 2.8 | 3.9 | 3.5 | 2.1 | 1.4 | 8.7 |
| mean      | 2.6 | 2.2 | 3.7 | 2.7 | 1.4 | 1.3 | 5.9 |

1969.

|           |     |     |     |     |     |     |     |
|-----------|-----|-----|-----|-----|-----|-----|-----|
| May       | 2.9 | 2.5 | 3.9 | 3.1 | 1.6 | 1.5 | 7.0 |
| June      | 2.4 | 1.7 | 3.4 | 2.2 | 1.1 | 1.1 | 4.1 |
| July      | 2.7 | 2.3 | 3.7 | 2.9 | 1.7 | 1.2 | 6.1 |
| August    | 2.6 | 1.7 | 3.5 | 2.3 | 1.0 | 1.3 | 4.1 |
| September | 3.1 | 2.5 | 3.9 | 3.5 | 1.7 | 1.8 | 9.0 |
| October   | 3.1 | 2.7 | 3.3 | 3.0 | 1.6 | 1.4 | 7.6 |
| mean      | 2.8 | 2.2 | 3.6 | 2.8 | 1.5 | 1.4 | 6.3 |

## 3. Air pressure factors

| mean<br>mm Hg<br>day and<br>night | trend<br>mm Hg<br>day and<br>night |
|-----------------------------------|------------------------------------|
|-----------------------------------|------------------------------------|

|     |       |
|-----|-------|
| 763 | +0.19 |
| 762 | +0.03 |
| 763 | +0.13 |
| 761 | -0.45 |
| 758 | -0.08 |
| 760 | -0.03 |
| 761 | -0.04 |

|     |       |
|-----|-------|
| 762 | -0.22 |
| 761 | +0.04 |
| 761 | +0.61 |
| 761 | +0.20 |
| 762 | -0.33 |
| 765 | -0.03 |
| 763 | +0.05 |





Table 8 (cont'd)

## 4. Humidity factors.

|           | mean<br>v.p.d<br>day<br>mm Hg | mean<br>Rh<br>day<br>% | mean<br>Rh<br>night<br>% | min.<br>Rh<br>day<br>% | max.<br>Rh<br>night<br>% | Rh<br>range<br>night<br>and<br>day | total<br>mm<br>rain<br>day | total<br>mm<br>rain<br>night | total<br>mm<br>rain<br>day and<br>night | no.of<br>days<br>with<br>rain | no.of<br>nights<br>with<br>rain |
|-----------|-------------------------------|------------------------|--------------------------|------------------------|--------------------------|------------------------------------|----------------------------|------------------------------|-----------------------------------------|-------------------------------|---------------------------------|
| 1968      |                               |                        |                          |                        |                          |                                    |                            |                              |                                         |                               |                                 |
| May       | 2.6                           | 74                     | 86                       | 58                     | 93                       | 37                                 | 18                         | 57                           | 75                                      | 10                            | 11                              |
| June      | 4.4                           | 71                     | 81                       | 52                     | 85                       | 40                                 | 41                         | 69                           | 110                                     | 11                            | 8                               |
| July      | 3.6                           | 75                     | 86                       | 60                     | 92                       | 35                                 | 87                         | 51                           | 138                                     | 7                             | 7                               |
| August    | 4.7                           | 71                     | 84                       | 53                     | 91                       | 41                                 | 41                         | 11                           | 52                                      | 7                             | 4                               |
| September | 2.8                           | 79                     | 82                       | 61                     | 93                       | 32                                 | 19                         | 28                           | 47                                      | 9                             | 6                               |
| October   | 1.9                           | 81                     | 88                       | 71                     | 93                       | 25                                 | 36                         | 36                           | 72                                      | 10                            | 9                               |
| mean      | 3.3                           | 75                     | 85                       | 59                     | 91                       | 35                                 | sum<br>242                 | 252                          | 494                                     | 54                            | 23                              |
| 1969.     |                               |                        |                          |                        |                          |                                    |                            |                              |                                         |                               |                                 |
| May       | 2.5                           | 76                     | 86                       | 63                     | 91                       | 31                                 | 47                         | 44                           | 91                                      | 7                             | 8                               |
| June      | 5.1                           | 66                     | 78                       | 49                     | 84                       | 40                                 | 14                         | 16                           | 30                                      | 7                             | 6                               |
| July      | 5.5                           | 68                     | 80                       | 53                     | 86                       | 37                                 | 43                         | 10                           | 53                                      | 5                             | 3                               |
| August    | 6.2                           | 68                     | 81                       | 49                     | 89                       | 43                                 | 34                         | 72                           | 106                                     | 9                             | 10                              |
| September | 4.7                           | 66                     | 77                       | 51                     | 86                       | 39                                 | 5                          | 13                           | 18                                      | 4                             | 7                               |
| October   | 2.2                           | 78                     | 85                       | 62                     | 81                       | 19                                 | 15                         | 4                            | 19                                      | 4                             | 2                               |
| mean      | 4.4                           | 70                     | 81                       | 55                     | 86                       | 35                                 | sum<br>158                 | 159                          | 317                                     | 36                            | 36                              |

## 30-years mean precipitation mm

|           |    |
|-----------|----|
| May       | 40 |
| June      | 56 |
| July      | 65 |
| August    | 76 |
| September | 50 |
| October   | 58 |



Table 9

SIMPLE CORRELATIONS BETWEEN CATCH AND WEATHER FACTORS: SIGN. AT 5 % LEVEL.

| factor                            | 1968 |   |   |   |   |   | 1969 |   |   |   |   |   | total |   |     |
|-----------------------------------|------|---|---|---|---|---|------|---|---|---|---|---|-------|---|-----|
|                                   | M    | J | J | A | S | O | sum  | M | J | J | A | S |       | O | sum |
| mean day temp.                    |      | + | + | + |   |   | 3    |   |   | + | + |   |       | 2 | 5   |
| mean night temp.                  |      | + |   | + |   |   | 2    |   | + |   | + |   |       | 2 | 4   |
| mean day and night temp.          |      |   | + | + | + |   | 3    |   | + |   | + |   |       | 2 | 5   |
| max.temp.night                    |      |   |   | + |   |   | 1    |   | + | + |   | + |       | 3 | 4   |
| min.temp. night                   |      |   |   | + |   |   | 2    |   | + |   | + |   |       | 2 | 4   |
| max.temp day                      |      |   |   | + | + |   | 2    |   |   |   |   |   |       | 0 | 2   |
| temp. range night                 |      |   |   |   |   |   | 0    |   | - |   |   |   |       | 1 | 1   |
| temp.range day                    |      |   |   | + | + |   | 2    |   | + |   |   |   |       | 1 | 3   |
| mean night temp. <sup>2</sup>     |      |   |   |   |   | + | 1    |   |   |   |   |   |       | 0 | 1   |
| max.day temp. <sup>2</sup>        |      |   |   | - | - |   | 2    |   |   |   |   |   |       | 0 | 2   |
| mean m/s night                    |      |   |   |   | - |   | 1    |   |   |   |   |   |       | 0 | 1   |
| max. m/s night                    |      |   |   | - | - |   | 2    |   |   |   |   |   |       | 0 | 2   |
| mean m/s night <sup>2</sup>       | -    |   |   | - | - | - | 4    | - |   |   | - |   |       | 2 | 6   |
| mean v.p.d. day                   |      |   |   | + |   |   | 1    |   |   |   |   |   |       | 0 | 1   |
| mean Rh day                       |      |   |   | - |   |   | 1    |   |   |   |   |   |       | 0 | 1   |
| mean Rh night                     |      |   |   |   |   |   | 0    |   |   |   |   | + |       | 1 | 1   |
| min.Rh day                        |      |   |   | - |   |   | 1    |   |   |   |   |   |       | 0 | 1   |
| mm rain day                       |      |   |   | - |   |   | 1    |   |   |   |   | - |       | 1 | 2   |
| mm rain day and night             |      |   |   | - |   |   | 1    |   |   |   |   |   |       | 0 | 1   |
| mm rain day <sup>2</sup>          |      |   |   |   |   |   | 0    |   |   |   |   | - |       | 1 | 1   |
| trend mm Hg <sup>2</sup>          |      |   |   |   |   |   | 1    |   |   |   | + |   |       | 1 | 2   |
| mean night temp. x mean night m/s |      |   |   |   | + |   | 1    |   |   |   |   |   |       | 0 | 1   |

| year | month | sign.pos. | sign.neg. | sum |
|------|-------|-----------|-----------|-----|
|------|-------|-----------|-----------|-----|

|      |       |   |   |    |
|------|-------|---|---|----|
| 1968 | May   | 1 | 1 | 2  |
|      | June  | 2 | 0 | 2  |
|      | July  | 9 | 7 | 16 |
|      | Aug.  | 5 | 4 | 9  |
|      | Sept. | 1 | 1 | 2  |

|     |    |    |    |
|-----|----|----|----|
| sum | 18 | 13 | 31 |
|-----|----|----|----|

|      |       |   |   |   |
|------|-------|---|---|---|
| 1969 | May   | 1 | 1 | 2 |
|      | June  | 5 | 1 | 6 |
|      | July  | 0 | 0 | 0 |
|      | Aug.  | 2 | 1 | 3 |
|      | Sept. | 6 | 2 | 8 |

|     |    |   |    |
|-----|----|---|----|
| sum | 14 | 5 | 19 |
|-----|----|---|----|

+ = pos.correlation  
 - = neg.correlation





Table 10

## SIGNIFICANT PARTIAL REGRESSIONS

| 1968                | MEAN NIGHT TEMP | MEAN NIGHT M/S | MEAN NIGHT M/S <sup>2</sup> | MEAN DAY TEMP | MAX DAY TEMP | MAX DAY TEMP <sup>2</sup> | MEAN DAY VPD | SUM |
|---------------------|-----------------|----------------|-----------------------------|---------------|--------------|---------------------------|--------------|-----|
| M                   | +               | —              |                             |               |              |                           |              | 2   |
| J                   |                 | —              |                             |               |              |                           |              | 1   |
| J                   | +               | —              |                             |               |              |                           |              | 2   |
| A                   | +               | —              |                             |               |              |                           |              | 2   |
| S                   | +               | —              |                             |               |              |                           |              | 2   |
| O                   | +               | —              |                             |               |              |                           |              | 2   |
| SUM                 | 5               | 6              |                             | 0             |              |                           |              | 11  |
| 3-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   | +               | —              |                             |               |              |                           |              | 2   |
| J                   |                 | —              |                             |               |              |                           |              | 1   |
| J                   | +               | —              |                             |               |              |                           |              | 2   |
| A                   | +               | —              |                             |               |              |                           |              | 2   |
| S                   | +               | —              |                             |               |              |                           |              | 2   |
| O                   | +               | —              |                             |               |              |                           |              | 2   |
| SUM                 | 5               | 6              |                             | 0             |              |                           |              | 11  |
| 6-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   |                 | —              |                             |               |              |                           |              | 2   |
| J                   |                 | —              |                             |               |              |                           |              | 1   |
| J                   | ++              | +              |                             |               |              |                           |              | 8   |
| A                   | +               | —              |                             |               |              |                           |              | 8   |
| S                   | +               | —              |                             |               |              |                           |              | 1   |
| O                   | +               | +              |                             |               |              |                           |              | 2   |
|                     | 323             | 122            | 312                         | 000           | 111          | 000                       |              | 2   |
| SUM                 | 8               | 5              | 6                           | 0             | 3            | 0                         |              | 22  |
| 8-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   | +               | +              | —                           |               |              |                           |              | 5   |
| J                   | —               | —              | —                           | +             | +            |                           |              | 7   |
| J                   | ++              | +              | —                           | —             | —            |                           |              | 10  |
| A                   | ++              | +              | —                           | —             | —            | +                         |              | 12  |
| S                   | —               | —              | —                           | —             | —            |                           |              | 6   |
| O                   | ++              | +              | —                           | +             | +            |                           |              | 6   |
|                     | 355             | 123            | 342                         | 133           | 322          | 31                        |              |     |
| SUM                 | 13              | 6              | 9                           | 7             | 7            | 4                         |              | 46  |

| 1969                | MEAN NIGHT TEMP | MEAN NIGHT M/S | MEAN NIGHT M/S <sup>2</sup> | MEAN DAY TEMP | MAX DAY TEMP | MAX DAY TEMP <sup>2</sup> | MEAN DAY VPD | SUM |
|---------------------|-----------------|----------------|-----------------------------|---------------|--------------|---------------------------|--------------|-----|
| M                   | +               | —              |                             |               |              |                           |              | 2   |
| J                   | +               | —              |                             |               |              |                           |              | 1   |
| J                   |                 | —              |                             |               |              |                           |              |     |
| A                   | +               | —              |                             |               |              |                           |              | 2   |
| S                   | +               | —              |                             |               |              |                           |              | 2   |
| O                   | +               | —              |                             |               |              |                           |              | 2   |
| SUM                 | 5               | 4              |                             | 0             |              |                           |              | 9   |
| 3-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   | +               | —              |                             |               |              |                           |              | 2   |
| J                   | +               | —              |                             |               |              |                           |              |     |
| J                   |                 | —              |                             |               |              |                           |              |     |
| A                   | +               | —              |                             |               |              |                           |              | 3   |
| S                   |                 | —              |                             |               |              |                           |              | 2   |
| O                   |                 |                |                             |               |              |                           |              | 1   |
|                     | 1               | 1              | 122                         | 000           | 010          | 000                       |              |     |
| SUM                 | 1               | 1              | 5                           | 0             | 1            | 0                         |              | 8   |
| 6-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   |                 | —              |                             |               |              |                           |              | 2   |
| J                   |                 | —              |                             |               |              |                           |              |     |
| J                   |                 | —              |                             |               |              |                           |              |     |
| A                   | +               | —              |                             |               |              |                           |              | 3   |
| S                   |                 | —              |                             |               |              |                           |              | 2   |
| O                   |                 |                |                             |               |              |                           |              | 1   |
|                     | 1               | 1              | 122                         | 000           | 010          | 000                       |              |     |
| SUM                 | 1               | 1              | 5                           | 0             | 1            | 0                         |              | 8   |
| 8-FACTORS' ANALYSIS |                 |                |                             |               |              |                           |              |     |
| M                   | +               | —              | +                           |               |              |                           |              | 5   |
| J                   |                 | —              | ++                          |               |              |                           |              | 9   |
| J                   | +               | —              | +                           |               |              |                           |              | 10  |
| A                   | +               | +              | —                           |               |              |                           |              | 7   |
| S                   |                 | —              | —                           |               |              |                           |              | 4   |
| O                   |                 | +              | ++                          |               |              |                           |              | 8   |
|                     | 221             | 311            | 323                         | 243           | 252          | 221                       |              |     |
| SUM                 | 5               | 5              | 8                           | 9             | 9            | 5                         |              | 43  |

The signs in the table (+++) represent from the left to the right for every factor calculation I, calculation II and the mean of calculation I and II.

+ pos. regression  
— neg. regression



Table 11

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN LOG CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN NIGHT TEMPERATURE.

Three factors' calculation.

| month     | year | d.f. | P. regression | S.E. (+) | t    | P           | Diff. x)<br>°C. |
|-----------|------|------|---------------|----------|------|-------------|-----------------|
| May       | 1968 | 26   | +0.16861      | 0.03777  | 4.46 | 0.001       | -2.4            |
|           | 1969 | 26   | +0.10153      | 0.04366  | 2.33 | 0.05-0.02   | -1.9            |
| June      | 1968 | 25   | +0.01620      | 0.03064  | 0.53 | -           | -0.7            |
|           | 1969 | 25   | +0.07255      | 0.02246  | 3.23 | 0.005-0.001 | -1.4            |
| July      | 1968 | 26   | +0.17186      | 0.04247  | 4.05 | 0.001       | -4.0            |
|           | 1969 | 26   | +0.05779      | 0.03944  | 1.47 | (0.2-0.1)   | -1.1            |
| August    | 1968 | 26   | +0.08403      | 0.03144  | 2.67 | 0.02-0.01   | -1.7            |
|           | 1969 | 26   | +0.04904      | 0.02365  | 2.07 | 0.05-0.02   | -1.5            |
| September | 1968 | 25   | +0.13329      | 0.02972  | 4.49 | 0.001       | -0.5            |
|           | 1969 | 25   | +0.13943      | 0.03637  | 3.87 | 0.001       | -0.2            |
| October   | 1968 | 26   | +0.10128      | 0.02676  | 3.78 | 0.001       | -0.5            |

Mean six factors' calculation.

|           |      |    |          |         |      |             |
|-----------|------|----|----------|---------|------|-------------|
| May       | 1968 | 16 | +0.13787 | 0.06593 | 2.08 | (0.1-0.05)  |
|           | 1969 | 16 | +0.05249 | 0.07131 | 0.74 | (0.5-0.4)   |
| June      | 1968 | 15 | +0.00574 | 0.05644 | 0.10 | -           |
|           | 1969 | 15 | +0.06779 | 0.05286 | 1.28 | (0.4-0.2)   |
| July      | 1968 | 16 | +0.14899 | 0.04194 | 3.55 | 0.005-0.001 |
|           | 1969 | 16 | +0.05000 | 0.07572 | 0.66 | -           |
| August    | 1968 | 16 | +0.08549 | 0.03891 | 2.20 | 0.05-0.01   |
|           | 1969 | 16 | +0.05137 | 0.02835 | 1.81 | (0.1-0.05)  |
| September | 1968 | 15 | +0.12754 | 0.06285 | 2.03 | (0.1-0.05)  |
|           | 1969 | 15 | +0.14839 | 0.07941 | 1.81 | (0.1-0.05)  |
| October   | 1968 | 16 | +0.13767 | 0.05003 | 3.75 | 0.005-0.001 |

Mean eight factors' calculation.

|           |      |    |          |         |      |             |
|-----------|------|----|----------|---------|------|-------------|
| May       | 1968 | 12 | +0.16845 | 0.00451 | 3.96 | 0.01-0.005  |
|           | 1969 | 12 | -0.01363 | 0.03652 | 0.37 | -           |
| June      | 1968 | 11 | -0.16108 | 0.04125 | 3.90 | 0.01-0.005  |
|           | 1969 | 11 | -0.03766 | 0.03551 | 1.06 | (0.4-0.01)  |
| July      | 1968 | 12 | +0.11919 | 0.03317 | 3.59 | 0.02-0.01   |
|           | 1969 | 12 | +0.00538 | 0.03808 | 0.14 | -           |
| August    | 1968 | 12 | +0.13689 | 0.02986 | 4.58 | 0.005-0.001 |
|           | 1969 | 12 | +0.04328 | 0.01833 | 2.36 | 0.05-0.02   |
| September | 1968 | 11 | -0.22856 | 0.15444 | 1.47 | (0.2-0.1)   |
|           | 1969 | 11 | +0.08295 | 0.05038 | 1.64 | (0.2-0.4)   |
| October   | 1968 | 12 | +0.13109 | 0.05330 | 2.45 | 0.05-0.02   |

x) Difference between the monthly mean night temperature and the corresponding 30-years mean day and night temperature.





Table 11

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN LOG CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN NIGHT TEMPERATURE.

Three factors' calculation.

| month     | year | d.f. | P. regression | S.E. (+) | t    | P           | Diff. x)<br>°C. |
|-----------|------|------|---------------|----------|------|-------------|-----------------|
| May       | 1968 | 26   | +0.16861      | 0.03777  | 4.46 | 0.001       | -2.4            |
|           | 1969 | 26   | +0.10153      | 0.04366  | 2.33 | 0.05-0.02   | -1.9            |
| June      | 1968 | 25   | +0.01620      | 0.03064  | 0.53 | -           | -0.7            |
|           | 1969 | 25   | +0.07255      | 0.02246  | 3.23 | 0.005-0.001 | -1.4            |
| July      | 1968 | 26   | +0.17186      | 0.04247  | 4.05 | 0.001       | -4.0            |
|           | 1969 | 26   | +0.05779      | 0.03944  | 1.47 | (0.2-0.1)   | -1.1            |
| August    | 1968 | 26   | +0.08403      | 0.03144  | 2.67 | 0.02-0.01   | -1.7            |
|           | 1969 | 26   | +0.04904      | 0.02365  | 2.07 | 0.05-0.02   | -1.5            |
| September | 1968 | 25   | +0.13329      | 0.02972  | 4.49 | 0.001       | -0.5            |
|           | 1969 | 25   | +0.13943      | 0.03637  | 3.87 | 0.001       | -0.2            |
| October   | 1968 | 26   | +0.10128      | 0.02676  | 3.78 | 0.001       | -0.5            |

Mean six factors' calculation.

|           |      |    |          |         |      |             |
|-----------|------|----|----------|---------|------|-------------|
| May       | 1968 | 16 | +0.13787 | 0.06593 | 2.08 | (0.1-0.05)  |
|           | 1969 | 16 | +0.05249 | 0.07131 | 0.74 | (0.5-0.4)   |
| June      | 1968 | 15 | +0.00574 | 0.05644 | 0.10 | -           |
|           | 1969 | 15 | +0.06779 | 0.05286 | 1.28 | (0.4-0.2)   |
| July      | 1968 | 16 | +0.14899 | 0.04194 | 3.55 | 0.005-0.001 |
|           | 1969 | 16 | +0.05000 | 0.07572 | 0.66 | -           |
| August    | 1968 | 16 | +0.08549 | 0.03891 | 2.20 | 0.05-0.01   |
|           | 1969 | 16 | +0.05137 | 0.02835 | 1.81 | (0.1-0.05)  |
| September | 1968 | 15 | +0.12754 | 0.06285 | 2.03 | (0.1-0.05)  |
|           | 1969 | 15 | +0.14839 | 0.07941 | 1.81 | (0.1-0.05)  |
| October   | 1968 | 16 | +0.13767 | 0.05003 | 3.75 | 0.005-0.001 |

Mean eight factors' calculation.

|           |      |    |          |         |      |             |
|-----------|------|----|----------|---------|------|-------------|
| May       | 1968 | 12 | +0.16845 | 0.00451 | 3.96 | 0.01-0.005  |
|           | 1969 | 12 | -0.01363 | 0.03652 | 0.37 | -           |
| June      | 1968 | 11 | -0.16108 | 0.04125 | 3.90 | 0.01-0.005  |
|           | 1969 | 11 | -0.03766 | 0.03551 | 1.06 | (0.4-0.01)  |
| July      | 1968 | 12 | +0.11919 | 0.03317 | 3.59 | 0.02-0.01   |
|           | 1969 | 12 | +0.00538 | 0.03808 | 0.14 | -           |
| August    | 1968 | 12 | +0.13689 | 0.02986 | 4.58 | 0.005-0.001 |
|           | 1969 | 12 | +0.04328 | 0.01833 | 2.36 | 0.05-0.02   |
| September | 1968 | 11 | -0.22856 | 0.15444 | 1.47 | (0.2-0.1)   |
|           | 1969 | 11 | +0.08295 | 0.05038 | 1.64 | (0.2-0.4)   |
| October   | 1968 | 12 | +0.13109 | 0.05330 | 2.45 | 0.05-0.02   |

x) Difference between the monthly mean night temperature and the corresponding 30-years mean day and night temperature.



Table 12.

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN DAY TEMPERATURE.

Six factors' calculation.

| month     | year | df. | P. regression | S.E. (+) | t    | P          |
|-----------|------|-----|---------------|----------|------|------------|
| May       | 1968 | 16  | -0.02930      | 0.07740  | 0.38 | -          |
|           | 1969 | 16  | +0.15546      | 0.07929  | 1.96 | (0.1-0.05) |
| June      | 1968 | 15  | +0.06561      | 0.07747  | 0.84 | (0.5-0.4)  |
|           | 1969 | 15  | +0.06180      | 0.09322  | 0.66 | -          |
| July      | 1968 | 16  | +0.01173      | 0.02924  | 0.40 | -          |
|           | 1969 | 16  | +0.01573      | 0.07393  | 0.21 | -          |
| August    | 1968 | 16  | -0.02842      | 0.03806  | 0.74 | (0.5-0.4)  |
|           | 1969 | 16  | +0.07486      | 0.05470  | 1.37 | (0.4-0.2)  |
| September | 1968 | 15  | +0.04180      | 0.09252  | 0.45 | -          |
|           | 1969 | 15  | +0.02279      | 0.04242  | 0.53 | -          |
| October   | 1968 | 16  | +0.02212      | 0.07002  | 0.32 | -          |

Eight factors' calculation.

|           |      |    |          |         |      |            | diff. x) |
|-----------|------|----|----------|---------|------|------------|----------|
| May       | 1968 | 12 | +0.03867 | 0.04172 | 2.88 | 0.05-0.02  | -0.5     |
|           | 1969 | 12 | -0.04726 | 0.04879 | 0.96 | (0.5-0.4)  | +0.1     |
| June      | 1968 | 11 | +0.12042 | 0.04176 | 2.88 | 0.05-0.02  | +1.8     |
|           | 1969 | 11 | +0.24222 | 0.06694 | 3.61 | 0.02-0.01  | +1.9     |
| July      | 1968 | 12 | -0.00235 | 0.03347 | 0.07 | -          | -1.3     |
|           | 1969 | 12 | -0.09239 | 0.03664 | 2.52 | 0.05-0.02  | +2.0     |
| August    | 1968 | 12 | -0.14691 | 0.05343 | 2.74 | 0.05-0.02  | +1.3     |
|           | 1969 | 12 | -0.01124 | 0.02827 | 0.40 | -          | +2.6     |
| September | 1968 | 11 | -0.39985 | 0.16022 | 2.49 | 0.05-0.02  | +2.1     |
|           | 1969 | 11 | +0.15611 | 0.04083 | 3.82 | 0.01-0.005 | +2.5     |
| October   | 1968 | 12 | +0.04806 | 0.05481 | 0.87 | (0.5-0.4)  | +1.2     |

x) Difference between the monthly mean day temperature and the corresponding 30-years mean day and night temperature.





Table 14.

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN DAY VAPOR PRESSURE DEFICITE.

Six factors' calculation.

| month     | year | df. | P. regression | S.E. (+) | t    | P         |
|-----------|------|-----|---------------|----------|------|-----------|
| May       | 1968 | 16  | -0.04759      | 0.08471  | 0.56 | -         |
|           | 1969 | 16  | -0.18325      | 0.10741  | 1.71 | (0.2-0.1) |
| June      | 1968 | 15  | +0.02701      | 0.06421  | 0.42 | -         |
|           | 1969 | 15  | -0.04717      | 0.08978  | 0.53 | -         |
| July      | 1968 | 16  | -0.02894      | 0.03855  | 0.75 | -         |
|           | 1969 | 16  | -0.00278      | 0.04561  | 0.06 | -         |
| August    | 1968 | 16  | +0.03076      | 0.02734  | 1.13 | -         |
|           | 1969 | 16  | +0.00184      | 0.04045  | 0.05 | -         |
| September | 1968 | 15  | -0.03465      | 0.08677  | 0.40 | -         |
|           | 1969 | 15  | +0.04794      | 0.09039  | 0.53 | -         |
| October   | 1968 | 16  | -0.02623      | 0.09671  | 0.27 | -         |

Eight factors' calculation.

|           |      |    |          |         |      |            |
|-----------|------|----|----------|---------|------|------------|
| May       | 1968 | 12 | +0.14614 | 0.16150 | 0.90 | (0.5-0.4)  |
|           | 1969 | 12 | -0.04371 | 0.05283 | 0.82 | (0.5-0.4)  |
| June      | 1968 | 11 | +0.02089 | 0.03199 | 0.65 | -          |
|           | 1969 | 11 | -0.34044 | 0.08697 | 3.91 | 0.01-0.005 |
| July      | 1968 | 12 | +0.11583 | 0.04964 | 2.33 | (0.1-0.05) |
|           | 1969 | 12 | +0.01411 | 0.02207 | 0.63 | -          |
| August    | 1968 | 12 | +0.08776 | 0.04611 | 1.90 | (0.1-0.2)  |
|           | 1969 | 12 | +0.05884 | 0.03190 | 1.85 | (0.2-0.1)  |
| September | 1968 | 11 | -0.05340 | 0.05052 | 1.05 | (0.4-0.2)  |
|           | 1969 | 11 | -0.09140 | 0.04191 | 2.18 | (0.1-0.05) |
| October   | 1968 | 12 | +0.16125 | 0.05944 | 2.71 | 0.05-0.02  |



Table 15.

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN LOG CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN NIGHT WIND VELOCITY.

Three factors' calculation.

| month     | year | d.f | P. regression | S.E. (+) | t    | P           | m/s |
|-----------|------|-----|---------------|----------|------|-------------|-----|
| May       | 1968 | 26  | -0.13402      | 0.04828  | 2.78 | 0.01-0.005  | 2.6 |
|           | 1969 | 26  | -0.13597      | 0.05846  | 2.33 | 0.05-0.02   | 2.5 |
| June      | 1968 | 25  | -0.10929      | 0.03703  | 2.95 | 0.01-0.005  | 2.3 |
|           | 1969 | 25  | +0.02276      | 0.04360  | 0.52 | -           | 1.7 |
| July      | 1968 | 26  | -0.10092      | 0.02758  | 3.66 | 0.005-0.001 | 1.9 |
|           | 1969 | 26  | -0.05491      | 0.05042  | 1.09 | (0.4-0.2)   | 2.3 |
| August    | 1968 | 26  | -0.17885      | 0.02887  | 6.20 | 0.001       | 1.8 |
|           | 1969 | 26  | -0.07137      | 0.02745  | 2.60 | 0.02-0.01   | 1.7 |
| September | 1968 | 25  | -0.21808      | 0.04500  | 4.84 | 0.001       | 1.8 |
|           | 1969 | 25  | -0.10082      | 0.04384  | 2.30 | 0.05-0.02   | 2.5 |
| October   | 1968 | 26  | -0.15176      | 0.05892  | 2.58 | 0.02-0.01   | 2.8 |

Mean six factors' calculation.

|           |      |    |          |         |      |            |  |
|-----------|------|----|----------|---------|------|------------|--|
| May       | 1968 | 16 | -0.03767 | 0.08739 | 0.49 | -          |  |
|           | 1969 | 16 | +0.07656 | 0.10254 | 0.75 | (0.5-0.4)  |  |
| June      | 1968 | 15 | -0.01850 | 0.07556 | 2.45 | 0.05-0.02  |  |
|           | 1969 | 15 | -0.00854 | 0.08182 | 0.10 | -          |  |
| July      | 1968 | 16 | -0.01173 | 0.02923 | 0.40 | -          |  |
|           | 1969 | 16 | +0.03923 | 0.09506 | 0.41 | -          |  |
| August    | 1968 | 16 | -0.14763 | 0.04122 | 3.58 | 0.01-0.005 |  |
|           | 1969 | 16 | -0.02433 | 0.03409 | 0.71 | -          |  |
| September | 1968 | 15 | -0.09016 | 0.15066 | 0.60 | -          |  |
|           | 1969 | 15 | -0.14462 | 0.08198 | 1.76 | (0.2-0.1)  |  |
| October   | 1968 | 16 | -0.15387 | 0.09976 | 1.54 | (0.2-0.1)  |  |

Mean eight factors' calculation.

|           |      |    |          |         |      |           | diff. x |
|-----------|------|----|----------|---------|------|-----------|---------|
| May       | 1968 | 12 | -0.04192 | 0.06564 | 0.63 | -         | -2.4    |
|           | 1969 | 12 | -0.05397 | 0.05153 | 1.04 | (0.4-0.2) | -1.9    |
| June      | 1968 | 11 | +0.05833 | 0.04152 | 1.40 | (0.4-0.2) | -0.7    |
|           | 1969 | 11 | -0.07036 | 0.06112 | 1.15 | (0.4-0.2) | -1.4    |
| July      | 1968 | 12 | +0.07257 | 0.04250 | 1.70 | (0.2-0.1) | -4.0    |
|           | 1969 | 12 | -0.03212 | 0.08285 | 0.39 | -         | -1.1    |
| August    | 1968 | 12 | -0.14850 | 0.02948 | 7.32 | 0.001     | -1.7    |
|           | 1969 | 12 | -0.02754 | 0.02084 | 1.32 | (0.4-0.2) | -1.5    |
| September | 1968 | 11 | -0.23481 | 0.08920 | 2.63 | 0.05-0.02 | -0.5    |
|           | 1969 | 11 | +0.04334 | 0.04482 | 0.96 | (0.4-0.2) | -0.2    |
| October   | 1968 | 12 | +0.00519 | 0.06746 | 0.07 | -         | -0.5    |

m/s = monthly mean night wind velocity

x) Difference between the monthly mean night temperature and the corresponding  
30-years mean night and day temperature.





Table 16.

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN CATCH BETWEEN ADJACENT NIGHTS  
ON THE MEAN NIGHT WIND VELOCITY.<sup>2</sup>

Six factors' calculation.

| month     | year | df. | P. regression | S.E. (+) | t    | P          |
|-----------|------|-----|---------------|----------|------|------------|
| May       | 1968 | 16  | -0.05236      | 0.03979  | 1.32 | (0.4-0.2)  |
|           | 1969 | 16  | -0.08983      | 0.03347  | 2.66 | 0.05-0.02  |
| June      | 1968 | 15  | -0.00283      | 0.02881  | 0.10 | -          |
|           | 1969 | 15  | +0.00195      | 0.08643  | 0.02 | -          |
| July      | 1968 | 16  | -0.02532      | 0.00823  | 3.08 | 0.01-0.005 |
|           | 1969 | 16  | -0.08488      | 0.04174  | 2.03 | (0.1-0.05) |
| August    | 1968 | 16  | -0.03095      | 0.01043  | 2.97 | 0.02-0.01  |
|           | 1969 | 16  | -0.06119      | 0.01836  | 3.33 | 0.02-0.01  |
| September | 1968 | 15  | -0.07682      | 0.06641  | 1.16 | (0.4-0.2)  |
|           | 1969 | 15  | -0.02533      | 0.02142  | 1.18 | (0.4-0.2)  |
| October   | 1968 | 16  | -0.03327      | 0.05266  | 0.63 | -          |

Eight factors' calculation.

|           |      |    |          |         |      |             |
|-----------|------|----|----------|---------|------|-------------|
| May       | 1968 | 12 | -0.06195 | 0.04911 | 1.26 | (0.4-0.2)   |
|           | 1969 | 12 | -0.05255 | 0.01572 | 3.34 | 0.02-0.01   |
| June      | 1968 | 11 | -0.02263 | 0.01349 | 1.67 | (0.2-0.1)   |
|           | 1969 | 11 | -0.10450 | 0.04603 | 2.27 | (0.1-0.05)  |
| July      | 1968 | 12 | -0.03364 | 0.00680 | 4.95 | 0.005-0.001 |
|           | 1969 | 12 | -0.06240 | 0.02346 | 2.65 | 0.05-0.02   |
| August    | 1968 | 12 | -0.03217 | 0.00682 | 4.71 | 0.005-0.001 |
|           | 1969 | 12 | -0.04639 | 0.01407 | 3.29 | 0.02-0.01   |
| September | 1968 | 11 | -0.11078 | 0.04392 | 2.52 | (0.1-0.05)  |
|           | 1969 | 11 | -0.04244 | 0.00882 | 4.81 | 0.005-0.001 |
| October   | 1968 | 12 | +0.04887 | 0.03596 | 1.35 | (0.4-0.2)   |



Table 17

ANALYSIS OF VARIANCE FOR LOG.CATCH ON SELECTED WEATHER FACTORS.Six factors' calculation.

| Year |                            | D.F. | S.S   | Variance<br>(M.S.) | F.     | P.   | Explained<br>variance % |
|------|----------------------------|------|-------|--------------------|--------|------|-------------------------|
| 1968 | <u>May I..</u>             |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 1.294 | .216               | 3.485  | -    | (72.3)                  |
|      | residual                   | 8    | 0.495 | .062               |        |      |                         |
|      | total                      | 14   | 1.789 |                    |        |      |                         |
|      | <u>May II</u>              |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 1.778 | .296               | 3.681  | 0.05 | 73.4                    |
|      | residual                   | 8    | 0.644 | .081               |        |      |                         |
|      | total                      | 14   | 2.422 |                    |        |      |                         |
|      | <u>May mean I,II</u>       |      |       |                    | 3.584  | 0.05 | 72.8                    |
|      | <u>June I</u>              |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 0.436 | .073               | 1.133  | -    | (45.9)                  |
|      | residual                   | 8    | 0.513 | .064               |        |      |                         |
|      | total                      | 14   | 0.949 |                    |        |      |                         |
|      | <u>June II</u>             |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 0.631 | .105               | 2.951  | -    | (71.7)                  |
|      | residual                   | 7    | 0.249 | .036               |        |      |                         |
|      | total                      | 13   | 0.880 |                    |        |      |                         |
|      | <u>June mean I,II</u>      |      |       |                    | 2.042  | -    | (58.8)                  |
|      | <u>July I</u>              |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 1.623 | .270               | 18.051 | 0.01 | 93.1                    |
|      | residual                   | 8    | 0.120 | .015               |        |      |                         |
|      | total                      | 14   | 1.743 |                    |        |      |                         |
|      | <u>July II</u>             |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 2.615 | .436               | 27.466 | 0.01 | 95.4                    |
|      | residual                   | 8    | 0.127 | .016               |        |      |                         |
|      | total                      | 14   | 2.742 |                    |        |      |                         |
|      | <u>July mean I,II</u>      |      |       |                    | 22.759 | 0.01 | 94.3                    |
|      | <u>August I</u>            |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 0.808 | .135               | 16.348 | 0.01 | 92.5                    |
|      | residual                   | 8    | 0.066 | .008               |        |      |                         |
|      | total                      | 14   | 0.874 |                    |        |      |                         |
|      | <u>August II</u>           |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 0.906 | .151               | 8.481  | 0.01 | 89.4                    |
|      | residual                   | 8    | 0.142 | .018               |        |      |                         |
|      | total                      | 14   | 1.048 |                    |        |      |                         |
|      | <u>August mean I,II</u>    |      |       |                    | 12.420 | 0.01 | 89.4                    |
|      | <u>September I</u>         |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 1.927 | .321               | 3.581  | 0.01 | 72.9                    |
|      | residual                   | 8    | 0.717 | .090               |        |      |                         |
|      | total                      | 14   | 2.644 |                    |        |      |                         |
|      | <u>September II</u>        |      |       |                    |        |      |                         |
|      | regression formula         | 6    | 0.485 | .081               | 1.008  | -    | (46.4)                  |
|      | residual                   | 7    | 0.562 | .081               |        |      |                         |
|      | total                      | 13   | 1.047 |                    |        |      |                         |
|      | <u>September mean I,II</u> |      |       |                    | 2.295  | -    | (59.6)                  |





Table 17 (cont'd)

|                            | D.F. | S.S.  | Variance<br>(M.S) | F.     | P.   | Explained<br>variance % |
|----------------------------|------|-------|-------------------|--------|------|-------------------------|
| <u>October I</u>           |      |       |                   |        |      |                         |
| regression formula         | 6    | 1.975 | .329              | 2.731  | -    | (67.2)                  |
| residual                   | 8    | 0.964 | .121              |        |      |                         |
| total                      | 14   | 2.939 |                   |        |      |                         |
| <u>October II</u>          |      |       |                   |        |      |                         |
| regression formula         | 6    | 1.278 | .213              | 1.989  | -    | (59.9)                  |
| residual                   | 8    | 0.857 | .107              |        |      |                         |
| total                      | 14   | 2.135 |                   |        |      |                         |
| <u>October mean I,II</u>   |      |       |                   | 2.360  | -    | (63.5)                  |
| <hr/>                      |      |       |                   |        |      |                         |
| 1969 <u>May I</u>          |      |       |                   |        |      |                         |
| regression formula         | 6    | 1.116 | .186              | 1.240  | -    | (48.2)                  |
| residual                   | 8    | 1.200 | .150              |        |      |                         |
| total                      | 14   | 2.316 |                   |        |      |                         |
| <u>May II</u>              |      |       |                   |        |      |                         |
| regression formula         | 6    | 2.571 | .429              | 5.994  | 0.05 | 81.8                    |
| residual                   | 8    | 0.572 | .071              |        |      |                         |
| total                      | 14   | 3.143 |                   |        |      |                         |
| <u>May mean I,II</u>       |      |       |                   | 3.617  | 0.05 | 65.0                    |
| <u>June I</u>              |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.286 | .048              | 0.452  | -    | (27.9)                  |
| residual                   | 8    | 0.740 | .106              |        |      |                         |
| total                      | 14   | 1.026 |                   |        |      |                         |
| <u>June II</u>             |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.743 | .124              | 3.508  | -    | (72.5)                  |
| residual                   | 7    | 0.282 | .035              |        |      |                         |
| total                      | 13   | 1.024 |                   |        |      |                         |
| <u>June mean I,II</u>      |      |       |                   | 1.980  | -    | (50.2)                  |
| <u>July I</u>              |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.686 | .114              | 1.006  | -    | (43.0)                  |
| residual                   | 8    | 0.909 | .114              |        |      |                         |
| total                      | 14   | 1.595 |                   |        |      |                         |
| <u>July II</u>             |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.268 | .045              | 2.533  | -    | (65.5)                  |
| residual                   | 8    | 0.141 | .018              |        |      |                         |
| total                      | 14   | 0.409 |                   |        |      |                         |
| <u>July mean I,II</u>      |      |       |                   | 1.770  | -    | (59.3)                  |
| <u>August I</u>            |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.733 | .122              | 27.586 | 0.01 | 95.4                    |
| residual                   | 8    | 0.035 | .004              |        |      |                         |
| total                      | 14   | 0.768 |                   |        |      |                         |
| <u>August II</u>           |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.438 | .073              | 2.002  | -    | (60.0)                  |
| residual                   | 8    | 0.292 | .036              |        |      |                         |
| total                      | 14   | 0.730 |                   |        |      |                         |
| <u>August mean I,II</u>    |      |       |                   | 14.794 | 0.01 | 77.7                    |
| <u>September I</u>         |      |       |                   |        |      |                         |
| regression formula         | 6    | 0.724 | .121              | 1.763  | -    | (60.2)                  |
| residual                   | 8    | 0.479 | .068              |        |      |                         |
| total                      | 14   | 1.203 |                   |        |      |                         |
| <u>September II</u>        |      |       |                   |        |      |                         |
| regression formula         | 6    | 2.369 | .395              | 9.495  | 0.01 | 89.1                    |
| residual                   | 7    | 0.291 | .042              |        |      |                         |
| total                      | 13   | 2.660 |                   |        |      |                         |
| <u>September mean I,II</u> |      |       |                   | 5.629  | 0.01 | 74.6                    |



Table 18      MONTHLY AVERAGE HOURLY TEMPERATURES

1968. t°C

| Month | 18-19 | 19-20 | 20-21 | 21-22 | 22-23 | 23-24 | 24-01 | 01-02 | 02-03 | 03-04 | 04-05 | 05-06 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| April |       | 12.1  | 11.1  | 10.5  | 10.6  | 10.2  | 9.8   | 9.4   | 9.1   | 8.9   | 8.4   |       |
| May   |       |       | 9.9   | 9.3   | 8.9   | 8.6   | 8.4   | 8.2   | 7.9   | 7.8   |       |       |
| June  |       |       |       | 15.7  | 14.9  | 14.3  | 13.9  | 13.6  | 13.4  |       |       |       |
| July  |       |       |       | 15.0  | 14.3  | 13.7  | 13.4  | 13.1  | 12.8  |       |       |       |
| Aug.  |       |       | 16.9  | 16.0  | 15.4  | 14.7  | 14.4  | 14.1  | 14.0  |       |       |       |
| Sept. |       | 14.7  | 14.0  | 13.6  | 13.2  | 12.9  | 12.7  | 12.4  | 12.3  | 11.6  | 11.8  |       |
| Okt.  | 9.9   | 9.7   | 9.3   | 9.1   | 8.7   | 8.8   | 8.7   | 8.7   | 8.7   | 8.7   | 8.7   | 8.7   |
| Nov.  | 5.0   | 4.9   | 4.7   | 4.6   | 4.6   | 4.6   | 4.9   | 4.4   | 4.3   | 4.3   | 4.3   | 4.3   |

1969. t°C

| Month | 18-19 | 19-20 | 20-21 | 21-22 | 22-23 | 23-24 | 24-01 | 01-02 | 02-03 | 03-04 | 04-05 | 05-06 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| April | 7.7   | 6.6   | 5.5   | 4.9   | 4.5   | 4.2   | 4.0   | 3.8   | 3.6   | 3.4   | 3.1   | 3.1   |
| May   |       |       | 10.0  | 9.5   | 9.3   | 9.2   | 9.0   | 8.8   | 8.6   | 8.3   |       |       |
| June  |       |       |       | 15.0  | 14.4  | 13.8  | 13.4  | 13.0  | 12.6  |       |       |       |
| July  |       |       |       | 17.6  | 16.8  | 16.1  | 15.8  | 15.6  | 15.4  |       |       |       |
| Aug.  |       |       | 17.5  | 16.6  | 15.9  | 15.4  | 15.0  | 14.7  | 14.4  | 14.8  |       |       |
| Sept. |       | 15.2  | 14.2  | 13.8  | 13.5  | 13.1  | 12.9  | 12.7  | 12.6  | 12.4  | 12.3  |       |
| Okt.  | 11.0  | 10.6  | 10.5  | 9.2   | 9.2   | 8.9   | 8.8   | 8.7   | 8.7   | 8.3   | 8.0   | 8.3   |





Table 19 INFLUENCE OF PRECIPITATION ON THE CHANGE IN CATCH

| A.Deviation from corrected catch <sup>1</sup><br>when rain occurred |      |                        |                 |                        |                        |     |             |               |                  | deviation °C from actual monthly<br>mean temp.when rain occurred |                               |                      |                        |     |    |    |     |
|---------------------------------------------------------------------|------|------------------------|-----------------|------------------------|------------------------|-----|-------------|---------------|------------------|------------------------------------------------------------------|-------------------------------|----------------------|------------------------|-----|----|----|-----|
| 1.day &<br>night<br>rain                                            |      | 2.day<br>rain          | 3.night<br>rain | sum<br>1,2,3           | day &<br>night<br>rain |     | day<br>rain | night<br>rain | monthly<br>total | mm rain                                                          | mean<br>day<br>night<br>temp. | mean<br>day<br>temp. | mean<br>night<br>temp. |     |    |    |     |
| 1968                                                                | June | +0.0315                | +0.0818         | -0.0093                | -0.0347                | 824 | 172         | 113           | 110              | 1                                                                | +0.2                          | +1.7                 | +2.3                   |     |    |    |     |
|                                                                     | July | -0.1409                | -0.2846         | -0.0255                | -0.1503                | 871 | 386         | 133           | 138              |                                                                  | -2.1                          | -1.3                 | -0.3                   |     |    |    |     |
|                                                                     | Aug. | -0.2558                | +0.0128         | -0.0945                | -0.1125                | 2   | 39          | 113           | 52               |                                                                  | -3.2                          | -1.7                 | +2.7                   |     |    |    |     |
| mean 1968                                                           |      |                        |                 |                        |                        |     |             |               |                  | -0.1217                                                          | -0.0633                       | -0.0431              | -0.0760                | 171 | 94 | 35 | 300 |
| 1969                                                                | June | +0.0815                | +0.2663         | +0.1392                | +0.1623                | 152 | 51          | 101           | 30               | 3                                                                | +0.8                          | +0.1                 | +2.6                   |     |    |    |     |
|                                                                     | July | (-0.4288) <sup>2</sup> | +0.1136         | (-0.1851) <sup>3</sup> | -0.1668                | 102 | 321         | 114           | 53               |                                                                  | +3.6                          | -0.9                 | +4.9                   |     |    |    |     |
|                                                                     | Aug. | -0.0657                | -0.0716         | -0.0635                | -0.0246                | 493 | 16          | 41            | 106              |                                                                  | -1.0                          | -2.5                 | +1.0                   |     |    |    |     |
| mean 1969                                                           |      |                        |                 |                        |                        |     |             |               |                  | -0.1377                                                          | +0.1028                       | +0.0059              | -0.0097                | 74  | 53 | 62 | 189 |

1) real catch corrected for weather factors in the 3-factors' analyses (see text.

2) 7.7,6.4 m/s,see below C. 31.7,max.temp.31°C,see below B,and text.

3) 24.7,max.temp.30.5°C,see below B,and text.

82<sup>5</sup> = no.of occasions

| B.Rainfall in connection with high<br>day maximum temperatures<br>(corrected as to the 8-factors'<br>calculation) |      |           |      |                   |      |         |     |  |  | C.Rainfall in connection with high<br>wind velocities (corrected as to<br>the 3-factors'calculation) |  |  |  |
|-------------------------------------------------------------------------------------------------------------------|------|-----------|------|-------------------|------|---------|-----|--|--|------------------------------------------------------------------------------------------------------|--|--|--|
| deviation max.day<br>temp °C                                                                                      |      | deviation |      | mean night<br>m/s |      |         |     |  |  |                                                                                                      |  |  |  |
| 17-18.6                                                                                                           | 1968 | +0.4214   | 29.0 | 27-28.6           | 1968 | -0.1757 | 4.7 |  |  |                                                                                                      |  |  |  |
| 24-25.7                                                                                                           | 1968 | +0.4289   | 30.5 | 7-8.7             | 1968 | -0.4376 | 6.4 |  |  |                                                                                                      |  |  |  |
| 31.7-1.8                                                                                                          | 1969 | +0.2042   | 31.0 | 16-17.8           | 1968 | -0.2558 | 6.0 |  |  |                                                                                                      |  |  |  |
| 19-20.8                                                                                                           | 1969 | +0.1840   | 28.0 | 7-8.7             | 1969 | -0.6269 | 4.9 |  |  |                                                                                                      |  |  |  |



Table 20

MONTHLY PARTIAL REGRESSION OF THE DIFF. IN LOG. CATCH OF SPECIES BETWEEN ADJACENT NIGHTS ON THE MEAN NIGHT TEMPERATURE, THE MAXIMUM DAY TEMPERATURE AND THE MEAN NIGHT WIND VELOCITY.

| <u>Mean night temperature.</u>   |      |      |               |                |      |             |
|----------------------------------|------|------|---------------|----------------|------|-------------|
| month                            | year | d.f. | P. regression | S.E. ( $\pm$ ) | t    | p           |
| May                              | 1968 | 26   | +0.10715      | 0.02426        | 4.41 | 0.001       |
|                                  | 1969 | 26   | +0.03834      | 0.03055        | 1.25 | (0.4-0.2)   |
| June                             | 1968 | 25   | +0.03089      | 0.01971        | 1.57 | (0.2-0.1)   |
|                                  | 1969 | 25   | +0.03436      | 0.01757        | 1.96 | (0.1-0.05)  |
| July                             | 1968 | 26   | +0.05756      | 0.02126        | 2.70 | 0.02-0.01   |
|                                  | 1969 | 26   | +0.00396      | 0.01793        | 0.22 | -           |
| August                           | 1968 | 26   | +0.04431      | 0.03095        | 1.43 | (0.2-0.1)   |
|                                  | 1969 | 26   | +0.04241      | 0.00920        | 4.61 | 0.001       |
| September                        | 1968 | 25   | +0.08509      | 0.02817        | 3.02 | 0.01-0.005  |
|                                  | 1969 | 25   | +0.06621      | 0.02458        | 2.69 | 0.02-0.01   |
| October                          | 1968 | 26   | +0.05577      | 0.01636        | 3.41 | 0.005-0.001 |
|                                  | 1969 | 26   | +0.00849      | 0.02800        | 0.30 | -           |
| <u>Maximum day temperature.</u>  |      |      |               |                |      |             |
| May                              | 1968 | 26   | -0.01256      | 0.01922        | 0.65 | -           |
|                                  | 1969 | 26   | -0.00352      | 0.01974        | 0.18 | -           |
| June                             | 1968 | 25   | -0.01046      | 0.01147        | 0.91 | -           |
|                                  | 1969 | 25   | +0.01839      | 0.01300        | 1.41 | (0.2-0.1)   |
| July                             | 1968 | 26   | +0.01335      | 0.00987        | 1.35 | (0.2-0.1)   |
|                                  | 1969 | 26   | -0.00095      | 0.00980        | 0.10 | -           |
| August                           | 1968 | 26   | +0.00749      | 0.01399        | 0.54 | -           |
|                                  | 1969 | 26   | +0.00443      | 0.00536        | 0.83 | (0.5-0.4)   |
| September                        | 1968 | 25   | -0.01431      | 0.02059        | 0.70 | (0.5-0.4)   |
|                                  | 1969 | 25   | +0.00934      | 0.01691        | 0.55 | -           |
| October                          | 1968 | 26   | -0.00933      | 0.02072        | 0.45 | -           |
|                                  | 1969 | 26   | +0.00212      | 0.02586        | 0.08 | -           |
| <u>Mean night wind velocity.</u> |      |      |               |                |      |             |
| May                              | 1968 | 26   | -0.10838      | 0.03101        | 3.50 | 0.005-0.001 |
|                                  | 1969 | 26   | -0.06680      | 0.04091        | 1.63 | (0.2-0.1)   |
| June                             | 1968 | 25   | -0.10435      | 0.02381        | 4.38 | 0.001       |
|                                  | 1969 | 25   | +0.06449      | 0.03412        | 1.89 | (0.1-0.05)  |
| July                             | 1968 | 26   | -0.04589      | 0.01380        | 3.33 | 0.005-0.001 |
|                                  | 1969 | 26   | +0.01272      | 0.02293        | 0.56 | -           |
| August                           | 1968 | 26   | -0.10949      | 0.02842        | 3.85 | 0.001       |
|                                  | 1969 | 26   | -0.04767      | 0.01068        | 4.46 | 0.001       |
| September                        | 1968 | 25   | -0.10895      | 0.04265        | 2.56 | 0.02-0.01   |
|                                  | 1969 | 25   | -0.03005      | 0.02963        | 1.01 | (0.4-0.2)   |
| October                          | 1968 | 26   | -0.12300      | 0.03603        | 3.41 | 0.005-0.001 |
|                                  | 1969 | 26   | +0.01337      | 0.02622        | 0.51 | -           |





Table 21

ANALYSIS OF VARIANCE FOR LOG.CATCH OF SPECIES ON MEAN NIGHT TEMPERATURE,  
MAX.DAY TEMPERATURE AND MEAN NIGHT WIND VELOCITY.

| year | month              | D.F. | S.S.  | Variance (P.C) | F.    | α.   | Explained variance |
|------|--------------------|------|-------|----------------|-------|------|--------------------|
| 1968 | May                |      |       |                |       |      |                    |
|      | regression formula | 3    | 1.237 | .412           | 11.70 | 0.01 | 57.6               |
|      | residual           | 26   | .909  | .038           |       |      |                    |
|      | total              | 29   | 2.146 |                |       |      |                    |
|      | June               |      |       |                |       |      |                    |
|      | regression formula | 3    | .531  | .177           | 6.69  | 0.01 | 44.2               |
|      | residual           | 25   | .671  | .027           |       |      |                    |
|      | total              | 28   | 1.202 |                |       |      |                    |
|      | July               |      |       |                |       |      |                    |
|      | regression formula | 3    | .544  | .181           | 10.41 | 0.01 | 54.6               |
|      | residual           | 26   | .453  | .017           |       |      |                    |
|      | total              | 29   | .997  |                |       |      |                    |
|      | August             |      |       |                |       |      |                    |
|      | regression formula | 3    | .556  | .185           | 8.05  | 0.01 | 48.2               |
|      | residual           | 26   | .599  | .023           |       |      |                    |
|      | total              | 29   | 1.155 |                |       |      |                    |
|      | September          |      |       |                |       |      |                    |
|      | regression formula | 3    | .674  | .225           | 3.81  | 0.05 | 31.4               |
|      | residual           | 25   | 1.474 | .059           |       |      |                    |
|      | total              | 28   | 2.148 |                |       |      |                    |
|      | October            |      |       |                |       |      |                    |
|      | regression formula | 3    | .807  | .269           | 6.00  | 0.01 | 40.9               |
|      | residual           | 26   | 1.166 | .045           |       |      |                    |
|      | total              | 29   | 1.973 |                |       |      |                    |
| 1969 | May                |      |       |                |       |      |                    |
|      | regression formula | 3    | .321  | .107           | 1.49  | -    | ( 14.7)            |
|      | residual           | 26   | 1.868 | .072           |       |      |                    |
|      | total              | 29   | 2.189 |                |       |      |                    |
|      | June               |      |       |                |       |      |                    |
|      | regression formula | 3    | .409  | .136           | 4.85  | 0.01 | 36.8               |
|      | residual           | 25   | .703  | .028           |       |      |                    |
|      | total              | 28   | 1.112 |                |       |      |                    |
|      | July               |      |       |                |       |      |                    |
|      | regression formula | 3    | .013  | .004           | 0.29  | -    | ( 3.2)             |
|      | residual           | 26   | .380  | .015           |       |      |                    |
|      | total              | 29   | .393  |                |       |      |                    |
|      | August             |      |       |                |       |      |                    |
|      | regression formula | 3    | .111  | .064           | 10.30 | 0.01 | 54.3               |
|      | residual           | 26   | .161  | .006           |       |      |                    |
|      | total              | 29   | .352  |                |       |      |                    |
|      | September          |      |       |                |       |      |                    |
|      | regression formula | 3    | .465  | .156           | 4.49  | 0.05 | 35.0               |
|      | residual           | 25   | .869  | .035           |       |      |                    |
|      | total              | 28   | 1.337 |                |       |      |                    |
|      | October            |      |       |                |       |      |                    |
|      | regression formula | 3    | .017  | .006           | 0.13  | -    | ( 1.7)             |
|      | residual           | 26   | 1.021 | .044           |       |      |                    |
|      | total              | 29   | 1.038 |                |       |      |                    |



Table 22. THE TEEN MOST COMMON SPECIES IN THE CATCH IN 1968 AND 1969

| <u>1968.</u>            |       | <u>1969.</u>      |       |
|-------------------------|-------|-------------------|-------|
| species                 | catch | species           | catch |
| 1.P.gamma               | 3609  | 1.A.exclamationis | 4917  |
| 2.A.exclamationis       | 3041  | 2.R.c-nigrum      | 2776  |
| 3.R.c-nigrum            | 2105  | 3.R.rubi          | 2171  |
| 4.R.rubi                | 1298  | 4.P.gamma         | 1164  |
| 5.E.morpheus            | 1266  | 5.E.morpheus      | 1010  |
| 6.T.pronuba             | 1164  | 6.H.alsines       | 723   |
| 7.A.segetum             | 906   | 7.S.trifolii      | 652   |
| 8.H.alsines             | 832   | 8.T.pronuba       | 632   |
| 9.P.monoglypha          | 732   | 9.A.segetum       | 606   |
| 10.A.corticea           | 660   | 10.P.monoglypha   | 555   |
| total                   |       | 14042             |       |
| % of total yearly catch |       | 58.8              |       |

Table 23

RELATIVE NUMBER OF FEMALES IN THE CATCH

| species         | catch 1968 | % females | catch 1969 | % females |
|-----------------|------------|-----------|------------|-----------|
| A.exclamationis | 3041       | 21.9      | 4917       | 21.1      |
| R.c-nigrum      | 2105       | 20.9      | 2776       | 29.5      |
| P.gamma         | 3609       | 39.9      | 1164       | 35.7      |
| R.rubi          | 1298       | 25.7      | 2171       | 30.4      |
| T.pronuba       | 1164       | 16.7      | 632        | 17.6      |





Table 24

WIND VELOCITY EXPERIMENTS.

Number of flight seconds at different wind velocities (max. 120 seconds )

A.Larger species.

| date | species         | expanse<br>of wings | m/s  |      |      |      |      |     |     |     | sum | t°C   |      | Rh<br>% |
|------|-----------------|---------------------|------|------|------|------|------|-----|-----|-----|-----|-------|------|---------|
|      |                 |                     | 1    | 2    | 3    | 4    | 5    | 6   | 7   | 8   |     | 8m/s  | 1m/s |         |
| 17.6 | A.segetum       | 46                  | 114  | 111  | 43   | 27   | 2    | 0   | 0   | 0   | 297 | 18.4  | 17.4 | 92      |
| 17.6 | P.oleracea      | 40                  | 100  | 98   | 16   | 5    | 2    | 0   | 0   | 0   | 221 | 18.2  | 17.3 | 93      |
| 17.6 | P.bassilinea    | 36                  | 84   | 94   | 18   | 6    | 0    | 0   | 0   | 0   | 202 | 18.0  | 17.3 | 94      |
| 19.6 | A.exclamationis | 38                  | 40   | 7    | 7    | 10   | 7    | 0   | 0   | 0   | 71  | 18.6  | 17.2 | 93      |
| 19.6 | A.exclamationis | 36                  | 79   | 24   | 5    | 0    | 3    | 0   | 0   | 0   | 111 | 17.5  | 16.7 | 94      |
| 19.6 | A.exclamationis | 39                  | 66   | 41   | 22   | 11   | 2    | 0   | 0   | 0   | 142 | 17.2  | 16.5 | 94      |
| 30.6 | P.monoglypha    | 52                  | 110  | 74   | 77   | 21   | 33   | 7   | 2   | 0   | 324 | 16.7  | 15.9 | 80      |
| 30.6 | A.exclamationis | 42                  | 67   | 17   | 5    | 3    | 0    | 0   | 0   | 0   | 92  | 16.4  | 15.7 | 80      |
| 30.6 | T.pronuba       | 56                  | 92   | 71   | 54   | 63   | 19   | 11  | 7   | 5   | 322 | 16.7  | 15.8 | 85      |
| 30.6 | T.pronuba       | 58                  | 93   | 73   | 77   | 63   | 20   | 12  | 17  | 2   | 357 | 16.2  | 15.4 | 86      |
| mean |                 |                     | 44.3 | 84.5 | 61.0 | 32.4 | 20.9 | 8.8 | 3.0 | 2.4 | 0.7 | 213.9 |      |         |

B.Smaller species

|      |               |    |      |      |      |      |     |     |   |   |     |       |      |    |
|------|---------------|----|------|------|------|------|-----|-----|---|---|-----|-------|------|----|
| 1.7  | R.putris      | 32 | 80   | 59   | 36   | 5    | 2   | 0   | 0 | 0 | 182 | 16.6  | 16.0 | 80 |
| 1.7  | P.strigilis   | 29 | 44   | 17   | 3    | 2    | 0   | 0   | 0 | 0 | 66  | 16.4  | 15.6 | 81 |
| 1.7  | P.strigilis   | 27 | 111  | 4    | 6    | 2    | 0   | 0   | 0 | 0 | 123 | 16.2  | 15.3 | 84 |
| 1.7  | P.strigilis   | 26 | 59   | 44   | 15   | 9    | 0   | 0   | 0 | 0 | 127 | 15.6  | 14.9 | 87 |
| 1.7  | E.morpheus    | 29 | 70   | 67   | 25   | 6    | 3   | 0   | 0 | 0 | 171 | 15.1  | 14.4 | 91 |
| 28.7 | H.blanda      | 33 | 56   | 34   | 13   | 5    | 2   | 0   | 0 | 0 | 110 | 21.6  | 20.6 | 67 |
| 28.7 | P.secalis     | 24 | 63   | 52   | 24   | 3    | 2   | 0   | 0 | 0 | 144 | 20.2  | 19.4 | 67 |
| 28.7 | P.latrunculus | 23 | 45   | 35   | 25   | 4    | 2   | 0   | 0 | 0 | 111 | 19.5  | 18.7 | 68 |
| 28.7 | P.secalis     | 25 | 65   | 48   | 24   | 3    | 7   | 0   | 0 | 0 | 147 | 19.8  | 19.0 | 68 |
| 28.7 | H.blanda      | 31 | 52   | 22   | 28   | 6    | 2   | 0   | 0 | 0 | 110 | 20.3  | 19.4 | 68 |
| mean |               |    | 27.9 | 64.5 | 38.2 | 19.9 | 4.2 | 2.0 | 0 | 0 | 0   | 129.1 |      |    |

C.P.ganna

|      |  |    |      |      |      |      |      |      |      |     |     |       |      |    |
|------|--|----|------|------|------|------|------|------|------|-----|-----|-------|------|----|
| 12.8 |  | 41 | 108  | 73   | 39   | 22   | 13   | 19   | 3    | 2   | 279 | 15.7  | 14.8 | 62 |
| 12.8 |  | 40 | 61   | 78   | 48   | 30   | 11   | 11   | 2    | 2   | 243 | 14.7  | 13.9 | 65 |
| 12.8 |  | 40 | 114  | 106  | 101  | 99   | 97   | 48   | 16   | 2   | 583 | 14.5  | 13.2 | 73 |
| 13.8 |  | 45 | 39   | 16   | 30   | 12   | 7    | 3    | 2    | 0   | 109 | 16.9  | 16.0 | 77 |
| 13.8 |  | 41 | 65   | 36   | 45   | 6    | 2    | 3    | 2    | 0   | 159 | 16.8  | 15.7 | 76 |
| 14.8 |  | 39 | 117  | 38   | 18   | 32   | 10   | 7    | 2    | 2   | 226 | 16.3  | 15.5 | 74 |
| 14.8 |  | 43 | 96   | 49   | 28   | 12   | 3    | 2    | 0    | 0   | 190 | 16.0  | 15.2 | 78 |
| 18.8 |  | 41 | 118  | 112  | 45   | 52   | 48   | 17   | 11   | 2   | 405 | 20.5  | 19.4 | 71 |
| 18.8 |  | 38 | 104  | 92   | 41   | 19   | 25   | 11   | 2    | 0   | 294 | 19.8  | 19.0 | 75 |
| 19.8 |  | 42 | 120  | 78   | 97   | 107  | 29   | 9    | 25   | 3   | 468 | 21.0  | 20.1 | 78 |
| mean |  |    | 41.0 | 94.2 | 67.8 | 49.2 | 39.1 | 24.5 | 13.0 | 6.7 | 1.3 | 303.7 |      |    |

Diff. as to wind sensitivity:

1.P.ganna - large species  $\chi^2_{(6)} = 11.13$  ,  $0.10 > P > 0.05$ 2.Large species-smallspecies  $\chi^2_{(4)} = 9.75$  ,  $0.05 > P > 0.02$



Table 25. Comparison between the numbers of small and large species caught at low and high wind velocity, respectively.

(Figures from the catch 1968)

| night                | mean<br>m/s | mean<br>t °C | no.of<br>small<br>moths | no.of<br>large<br>moths | no.of<br>moths | % small<br>moths                                  | % large<br>moths | % decrease<br>small<br>moths | % decrease<br>large<br>moths |
|----------------------|-------------|--------------|-------------------------|-------------------------|----------------|---------------------------------------------------|------------------|------------------------------|------------------------------|
| 1. 20-21.6           | 2.25        | 18.4         | 164                     | 652                     | 816            | 20.1                                              | 79.9             |                              |                              |
| 1. 21-22.6           | 3.95        | 14.8         | 53                      | 388                     | 441            | 12.8                                              | 86.2             | 67.7                         | 40.6                         |
| 2. 28-29.6           | 2.75        | 14.7         | 27                      | 120                     | 147            | 18.4                                              | 81.6             |                              |                              |
| 2. 29-30.6           | 3.45        | 14.2         | 13                      | 79                      | 92             | 14.2                                              | 85.8             | 51.8                         | 38.1                         |
| 3. 6-7.7             | 1.40        | 15.7         | 200                     | 393                     | 593            | 33.9                                              | 66.1             |                              |                              |
| 3. 7-8.7             | 7.24        | 13.0         | 4                       | 28                      | 32             | 12.0                                              | 88.0             | 98.0                         | 74.5                         |
| 4. 11-12.8           | 2.25        | 15.3         | 17                      | 227                     | 244            | 7.8                                               | 92.2             |                              |                              |
| 4. 12-13.8           | 4.13        | 13.6         | 3                       | 71                      | 74             | 4.2                                               | 95.8             | 82.4                         | 68.7                         |
| 5. 14-15.8           | 2.70        | 15.3         | 8                       | 235                     | 243            | 3.3                                               | 96.7             |                              |                              |
| 15-16.8              | 4.20        | 13.5         | 0                       | 97                      | 97             | 0.0                                               | 100.0            | 100.0                        | 58.7                         |
| low                  | 2.27        | 15.9         | 416                     | 1627                    | 2043           | 20.4                                              | 79.6             | 79.9                         | 56.1                         |
| high                 | 4.59        | 13.8         | 73                      | 663                     | 736            | 9.9                                               | 90.1             |                              |                              |
| transformed to small |             |              | (347)                   |                         | $\chi^2_{(1)}$ | on diff.in decrease in number = 37.74 $P < 0.001$ |                  |                              |                              |
|                      |             |              | (142)                   |                         |                |                                                   |                  |                              |                              |

Table 26. Comparison between *E.morpheus* and *A.exclamationis* as to the catch at high and low wind velocity, respectively.

(Figures from the catch 1968)

| night       | mean m/s | no.of <i>E.morpheus</i> | no.of <i>A.exclamationis</i> |
|-------------|----------|-------------------------|------------------------------|
| 1. 20-21.6  | 2.25     | 109                     | 261                          |
| 1. 21-22.6  | 3.95     | 22                      | 170                          |
| 2. 26-27.6  | 4.70     | 18                      | 136                          |
| 2. 27-28.6  | 5.95     | 0                       | 47                           |
| 3. 29-30.6  | 3.45     | 3                       | 33                           |
| 3. 30.6-1.7 | 0.60     | 59                      | 79                           |
| 4. 2-3.7    | 1.24     | 24                      | 47                           |
| 4. 3-4.7    | 2.49     | 29                      | 45                           |
| 5. 6-7.7    | 1.40     | 42                      | 46                           |
| 5. 7-8.7    | 7.24     | 1                       | 3                            |
| 6. 9-10.7   | 3.77     | 10                      | 23                           |
| 6. 10-11.7  | 1.24     | 66                      | 28                           |
| low         | 1.91     | 318                     | 597 (249)                    |
| high        | 4.27     | 65                      | 321 (134)                    |
|             |          |                         | $\chi^2_{(1)} = 51.7$        |
|             |          |                         | $P < 0.001$                  |

Small species = *E.morpheus*, *H.alsines*, *H.blanda*, *P.strigilis*, *R.plecta*.





Table 27. SPECIES USED IN THE FLIGHT START OBSERVATIONS.

| SPRING                         | no.of<br>males | no.of<br>females | sum |
|--------------------------------|----------------|------------------|-----|
| <i>Monima gothica</i>          | 14             | 1                | 15  |
| <i>Monima gracilis</i>         | 3              | 2                | 5   |
| <i>Monima incerta</i>          | 29             | 8                | 37  |
| <i>Monima opima</i>            | 1              | 1                | 2   |
| <i>Monima stabilis</i>         | 11             | 3                | 14  |
|                                | 58             | 15               | 73  |
| SUMMER                         |                |                  |     |
| <i>Abrostola tripartita</i>    | 3              | 0                | 3   |
| <i>Acronycta psi</i>           | 2              | 0                | 2   |
| <i>Agrotis exclamationis</i>   | 42             | 6                | 48  |
| <i>Agrotis segetum</i>         | 15             | 3                | 18  |
| <i>Cerapteryx graminis</i>     | 2              | 0                | 2   |
| <i>Craniophora ligustri</i>    | 1              | 0                | 1   |
| <i>Cucullia absinthii</i>      | 3              | 0                | 3   |
| <i>Cucullia umbratica</i>      | 4              | 0                | 4   |
| <i>Elaphria morpheus</i>       | 4              | 1                | 5   |
| <i>Euplexia lucipara</i>       | 2              | 0                | 2   |
| <i>Harmodia bicruris</i>       | 4              | 0                | 4   |
| <i>Hoplodrina alsines</i>      | 2              | 0                | 2   |
| <i>Hoplodrina blanda</i>       | 4              | 0                | 4   |
| <i>Hyphilare lithargyria</i>   | 6              | 1                | 7   |
| <i>Meristes trigrammica</i>    | 3              | 0                | 3   |
| <i>Parastichtis basilinea</i>  | 11             | 1                | 12  |
| <i>Parastichtis lithoxylea</i> | 6              | 0                | 6   |
| <i>Parastichtis monoglypha</i> | 8              | 0                | 8   |
| <i>Parastichtis obscura</i>    | 2              | 0                | 2   |
| <i>Parastichtis rurea</i>      | 3              | 0                | 3   |
| <i>Parastichtis secalis</i>    | 4              | 0                | 4   |
| <i>Parastichtis sublustris</i> | 1              | 0                | 1   |
| <i>Phytometra chrysitis</i>    | 1              | 0                | 1   |
| <i>Phytometra jota</i>         | 1              | 0                | 1   |
| <i>Plusia gamma</i>            | 11             | 2                | 13  |
| <i>Polia oleracea</i>          | 6              | 1                | 7   |
| <i>Polia persicaria</i>        | 5              | 2                | 7   |
| <i>Polia pisi</i>              | 2              | 0                | 2   |
| <i>Proculus latrunculus</i>    | 1              | 0                | 1   |
| <i>Proculus strigilis</i>      | 4              | 1                | 5   |
| <i>Rhyacia c-nigrum</i>        | 7              | 1                | 8   |
| <i>Rhyacia plecta</i>          | 2              | 0                | 2   |
| <i>Rhyacia putris</i>          | 3              | 0                | 3   |
| <i>Rhyacia rubi</i>            | 12             | 3                | 15  |
| <i>Sideridis pallens</i>       | 0              | 2                | 2   |
| <i>Scotogramma trifolii</i>    | 7              | 0                | 7   |
| <i>Stygiostola umbratica</i>   | 4              | 0                | 4   |
| <i>Triphaena pronuba</i>       | 19             | 2                | 21  |
|                                | 217            | 26               | 243 |
| AUTUMN                         |                |                  |     |
| <i>Agrotis segetum</i>         | 1              | 0                | 1   |
| <i>Amathes litura</i>          | 1              | 0                | 1   |
| <i>Amphitrota ravidia</i>      | 8              | 0                | 8   |
| <i>Euxoa obelisca</i>          | 1              | 0                | 1   |
| <i>Hydroecia micacea</i>       | 3              | 0                | 3   |
| <i>Palluperina testacea</i>    | 7              | 1                | 8   |
| <i>Plusia gamma</i>            | 8              | 1                | 9   |
| <i>Rhyacia c-nigrum</i>        | 23             | 5                | 28  |
| <i>Rhyacia rubi</i>            | 8              | 4                | 12  |
| <i>Rhyacia xanthographa</i>    | 10             | 1                | 11  |
| <i>Triphaena pronuba</i>       | 5              | 0                | 5   |
|                                | 75             | 12               | 87  |



DISTRIBUTION OF FLIGHT STARTS ON LUX-AREAS





Table 28 (cont'd)

## DISTRIBUTION OF FLIGHT STARTS ON LUX AREAS

| SUMMER                            |           |       |       |      |      |      |     |     |               |                    |                  |
|-----------------------------------|-----------|-------|-------|------|------|------|-----|-----|---------------|--------------------|------------------|
|                                   | Lux areas |       |       |      |      |      |     |     |               |                    |                  |
|                                   | 100-51    | 50-26 | 25-11 | 10-6 | 5-4  | 3-2  | 1-0 | 0   | No. of starts | mean min.          | mean fig. of lux |
| Midpoint of lux areas             | 75        | 37.5  | 17.5  | 7.5  | 4.5  | 2.5  | 0.5 | 0   |               |                    |                  |
| Mean starting minutes from 0 lux. | 53        | 43    | 34    | 26   | 22   | 17   | 8   | 0   |               |                    |                  |
| <hr/>                             |           |       |       |      |      |      |     |     |               |                    |                  |
| date                              |           |       |       |      |      |      |     |     |               |                    |                  |
| 15.6                              |           | 6     | 19    | 13   | 11   | 8    |     |     | 57            | 28.6               | 13.1             |
| 16.6                              | 3         | 2     | 7     | 11   | 8    | 9    | 1   |     | 41            | 27.0               | 13.5             |
| 17.6                              |           |       |       | 1    | 6    | 5    |     |     | 12            | 20.3               | 3.9              |
| 18.6                              |           |       | 5     | 6    | 3    | 13   | 3   | 1   | 31            | 20.5               | 5.8              |
| 19.6                              |           | 2     | 7     | 6    | 3    | 10   | 3   |     | 31            | 23.9               | 9.1              |
| 20.6                              |           |       | 9     | 9    | 10   | 17   |     |     | 45            | 23.3               | 6.9              |
| 21.6                              |           |       | 14    | 8    | 14   | 13   |     |     | 49            | 24.8               | 8.2              |
| 22.6                              |           |       | 11    | 12   | 12   | 13   | 4   | 3   | 55            | 21.9               | 6.8              |
| 23.6                              |           | 3     | 9     | 13   | 10   | 17   |     |     | 52            | 24.7               | 8.8              |
| 24.6                              |           | 4     | 7     | 4    | 2    | 8    | 1   |     | 26            | 27.0               | 12.8             |
| 25.6                              |           |       | 3     | 8    | 12   | 10   | 5   | 1   | 39            | 20.1               | 5.0              |
| 26.6                              |           | 1     | 4     | 1    | 3    | 6    | 1   |     | 16            | 23.8               | 9.0              |
| 27.6                              |           |       | 2     | 13   | 5    | 4    |     |     | 24            | 24.3               | 6.9              |
| 28.6                              |           |       |       | 4    | 6    | 9    | 3   | 2   | 24            | 17.2               | 3.4              |
| 29.6                              |           |       | 3     | 3    | 5    | 23   | 1   |     | 35            | 16.5               | 4.4              |
| 30.6                              |           |       | 8     | 5    | 2    | 3    | 1   | 2   | 21            | 24.0               | 9.3              |
| 1.7                               |           | 5     | 3     | 3    | 2    | 8    | 5   | 4   | 30            | 20.5               | 9.0              |
| 2.7                               |           |       |       | 7    | 7    | 3    | 2   |     | 19            | 21.2               | 4.9              |
| 3.7                               |           | 3     | 1     | 1    | 3    | 10   | 6   | 2   | 26            | 18.2               | 6.9              |
| 4.7                               |           |       |       | 4    | 5    | 6    | 1   |     | 16            | 20.3               | 4.3              |
| 26.7                              |           | 1     | 2     | 3    | 2    | 13   | 11  |     | 32            | 16.9               | 24.4             |
| 27.7                              |           |       | 2     | 12   | 5    | 2    |     |     | 22            | 25.4               | 7.7              |
| 30.7                              |           |       | 9     | 5    | 11   | 5    | 8   | 4   | 42            | 19.7               | 6.2              |
| 31.7                              |           | 2     | 7     | 2    | 6    | 1    | 2   |     | 20            | 27.1               | 12.2             |
| <hr/>                             |           |       |       |      |      |      |     |     |               |                    |                  |
| sum                               | 3         | 29    | 133   | 154  | 153  | 216  | 58  | 19  | 765           | $\bar{x}_1 = 22.4$ | $y_1 = 3.3$      |
| %                                 | 0.4       | 3.8   | 17.4  | 20.1 | 20.0 | 28.2 | 7.6 | 2.5 | 100           |                    |                  |
| <hr/>                             |           |       |       |      |      |      |     |     |               |                    |                  |
|                                   |           |       |       |      |      |      |     |     |               | S.D                |                  |
|                                   |           |       |       |      |      |      |     |     |               | 3.33               | 2.83             |



Table 28 (cont'd)

DISTRIBUTION OF FLIGHT STARTS ON LUX AREAS

AUTUMN.

|                                  | Lux areas |       |       |      |     |      |      |      |              |           |                  |
|----------------------------------|-----------|-------|-------|------|-----|------|------|------|--------------|-----------|------------------|
|                                  | 100-51    | 50-26 | 25-11 | 10-6 | 5-4 | 3-2  | 1-0  | 0    | No.of starts | Mean min. | Mean fig. of lux |
| Midpoint of lux areas            | 75        | 37.5  | 17.5  | 7.5  | 4.5 | 2.5  | 0.5  | 0    |              |           |                  |
| Mean start in minutes from 0 lux | 53        | 43    | 34    | 26   | 22  | 17   | 8    | 0    |              |           |                  |
| <hr/>                            |           |       |       |      |     |      |      |      |              |           |                  |
| date                             |           |       |       |      |     |      |      |      |              |           |                  |
| 19.8                             |           |       | 1     | 3    |     | 9    | 9    | 3    | 25           | 13.5      | 3.1              |
| 20.8                             |           |       | 1     | 1    | 2   | 5    | 1    |      | 10           | 19.7      | 4.7              |
| 5.9                              |           |       |       |      | 2   | 5    | 7    | 3    | 17           | 10.9      | 1.5              |
| 6.9                              |           |       |       | 1    | 1   | 3    | 6    | 2    | 13           | 11.3      | 1.7              |
| 12.9                             |           |       |       | 1    | 1   | 6    | 2    |      | 10           | 16.6      | 2.8              |
| 13.9                             |           |       |       | 1    | 2   | 4    | 8    | 5    | 20           | 10.1      | 1.5              |
| 14.9                             |           |       |       |      |     | 4    | 9    | 2    | 15           | 8.7       | 1.0              |
| 15.9                             |           |       |       |      | 1   | 4    | 5    | 5    | 15           | 8.7       | 1.1              |
| 10.10                            |           |       |       | 2    | 2   | 6    | 2    |      | 12           | 17.8      | 3.3              |
| 11.10                            |           |       |       |      | 1   | 1    | 7    | 3    | 12           | 7.9       | 0.9              |
| 12.10                            |           |       |       |      |     | 3    |      | 3    | 6            | 8.5       | 1.3              |
| <hr/>                            |           |       |       |      |     |      |      |      |              |           |                  |
| sum                              |           |       | 2     | 9    | 12  | 50   | 56   | 26   | 155          |           |                  |
| %                                |           |       | 1.3   | 5.8  | 7.7 | 32.3 | 36.1 | 16.8 | 100          |           |                  |
| <hr/>                            |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
|                                  |           |       |       |      |     |      |      |      |              |           |                  |
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Table 29      Flight start in relation to the light value one lux.  
Comparison between three Monima species.

| date | M.incerta | M.gothica | M.stabilis | Weather conditions  |
|------|-----------|-----------|------------|---------------------|
| 27.4 | +12       | + 4       | + 7        | clear               |
| 28.4 | - 5       | + 5       | + 1        | clear               |
| 29.4 | - 6       | +11       | - 6        | clear               |
| 30.4 | + 6       | + 1       | + 6        | clear               |
| 1.5  | + 4       | 0         | +12        | cloudy              |
| 2.5  | -10       | 0         | +12        | cloudy              |
| 3.5  | -12       | -10       | + 4        | cloudy              |
| 4.5  | - 4       | 0         | + 9        | cloudy              |
| 5.5  | - 2       | + 2       | + 5        | cloudy              |
| 6.5  | 0         | -22       | + 5        | cloudy              |
| 7.5  | -10       | -14       | 0          | cloudy,thunder,rain |
| 8.5  | + 3       | 0         | + 8        | half cloudy         |
| 9.5  | - 1       | - 2       | + 6        | cloudy              |
| 10.5 | + 8       | - 5       | +10        | clear               |
| 11.5 | +13       | - 3       | + 8        | clear               |
| 12.5 | + 8       | 0         | + 5        | clear               |
| 13.5 | 0         | - 3       | + 3        | cloudy              |
| 14.5 | +10       | + 1       | +20        | half cloudy         |
| 15.5 | -15       | -10       | - 4        | clear               |
| 16.5 | 0         | - 9       | - 3        | half cloudy         |
| 17.5 | + 6       |           | +23        | almost cloudy       |
| 18.5 | + 1       |           | + 2        | cloudy              |
| 19.5 | + 2       |           | - 6        | clear               |

+ = start in minutes before 1 lux.    - = start in minutes after 1 lux.

|      |       |       |       |
|------|-------|-------|-------|
| mean | +0.35 | -2.70 | +5.30 |
| S.D  | 7.49  | 4.72  | 7.18  |

M.incerta-M.stabilis: diff.of mean = 4.95. S.E of diff.=1.84, P = 0.05-0.01

M.gothica-M.stabilis: diff.of mean = 8.00, S.E of diff.=1.87, P = < 0.001



Table 30. FLIGHT START IN RELATION TO ONE LUX. SUMMER AND AUTUMN SPECIES

| Species          | no. of<br>starts | season | start in<br>relation<br>to 1 lux<br>minutes | controlled period |
|------------------|------------------|--------|---------------------------------------------|-------------------|
| A. exclamationis | 130              | summer | +13.9                                       | 15.6-4.7          |
| A. segetum       | 48               | summer | +12.1                                       | 15.6-4.7          |
|                  | 4                | autumn | + 2.0                                       | 13.9-15.9         |
| P. bassilinea    | 26               | summer | +12.8                                       | 15.6-4.7          |
| P. gamma         | 14               | summer | +16.2                                       | 16.6-30.7         |
|                  | 13               | autumn | +12.1                                       | 5.9 -12.10        |
| P. monoglypha    | 9                | summer | + 8.0                                       | 26.7-30.7         |
| R. c-nigrum      | 11               | summer | +19.6                                       | 16.6-3.7          |
|                  | 60               | autumn | - 0.7                                       | 5.9 -12.10        |
| R. rubi          | 28               | summer | +11.3                                       | 15.6-23.6         |
| R. xanthographa  | 10               | autumn | - 4.7                                       | 19.8-14.9         |
| T. pronuba       | 26               | summer | +15.0                                       | 25.6-31.7         |
|                  | 12               | autumn | + 0.6                                       | 5.9 -14.9         |
|                  |                  | summer | +13.6                                       |                   |
|                  |                  | autumn | + 1.9                                       |                   |





Table 31 . ARTIFICIAL TWILIGHT EXPERIMENT 1.

Observations on the time for the flight start.

| Time | Iux  | Sitting | Creeping | Flying | t°C  | Rh % |
|------|------|---------|----------|--------|------|------|
| 1900 | 3000 | 5       | 0        | 0      | 19.5 | 55   |
| 1903 | 1500 | 5       | 0        | 0      | 19.5 | 55   |
| 1906 | 750  | 5       | 0        | 0      | 19.6 | 55   |
| 1909 | 325  | 5       | 0        | 0      | 19.7 | 55   |
| 1912 | 160  | 5       | 0        | 0      | 19.8 | 55   |
| 1915 | 80   | 5       | 0        | 0      | 19.8 | 55   |
| 1918 | 60   | 5       | 0        | 0      | 19.8 | 55   |
| 1921 | 48   | 3       | 2        | 0      | 19.8 | 55   |
| 1924 | 34   | 3       | 1        | 1      | 19.8 | 55   |
| 1927 | 27   | 4       | 1        | 0      | 19.8 | 55   |
| 1930 | 16   | 2       | 2        | 1      | 19.8 | 54   |
| 1932 | 12   | 3       | 2        | 0      | 19.8 | 54   |
| 1935 | 10   | 2       | 3        | 0      | 19.8 | 54   |
| 1937 | 8    | 2       | 3        | 0      | 19.8 | 54   |
| 1939 | 7    | 3       | 2        | 0      | 19.8 | 54   |
| 1940 | 6    | 2       | 3        | 0      | 19.8 | 54   |
| 1942 | 5    | 1       | 3        | 1      | 19.7 | 54   |
| 1944 | 4    | 0       | 3        | 2      | 19.7 | 54   |
| 1949 | 3    | 0       | 2        | 3      | 19.7 | 54   |
| 1952 | 2    | 0       | 2        | 3      | 19.7 | 54   |
| 1956 | 1,5  | 0       | 1        | 4      | 19.6 | 54   |
| 2000 | 1,0  | 0       | 1        | 4      | 19.6 | 54   |
| 2005 | 0,5  | 0       | 1        | 4      | 19.6 | 54   |
| 2010 | 10   | 0       | 2        | 3      | 19.6 | 54   |
| 2012 | 30   | 3       | 2        | 0      | 19.6 | 54   |
| 2014 | 60   | 4       | 1        | 0      | 19.6 | 54   |
| 2016 | 120  | 5       | 0        | 0      | 19.6 | 54   |
| 2018 | 250  | 5       | 0        | 0      | 19.7 | 54   |
| 2020 | 500  | 5       | 0        | 0      | 19.7 | 54   |
| 2022 | 1000 | 5       | 0        | 0      | 19.7 | 54   |
| 2025 | 3000 | 5       | 0        | 0      | 19.7 | 54   |

Five A. exclamationis (males) were used in the experiment.

Temperature in the meteorological cage 1900 21°C, 2000 19°C.  
Relative humidity 1900 39 %, 2000 39 %.



Table 32 . ARTIFICIAL TWILIGHT EXPERIMENT 2.

| time | lux  | sitting | creeping | flying |                                    |
|------|------|---------|----------|--------|------------------------------------|
| 0900 | 4000 | 10      | 0        | 0      |                                    |
| 0930 | 1500 | 10      | 0        | 0      |                                    |
| 1000 | 1000 | 10      | 0        | 0      |                                    |
| 1030 | 500  | 10      | 0        | 0      |                                    |
| 1045 | 350  | 10      | 0        | 0      |                                    |
| 1100 | 250  | 10      | 0        | 0      |                                    |
| 1103 | 125  | 10      | 0        | 0      |                                    |
| 1106 | 80   | 9       | 1        | 0      |                                    |
| 1110 | 50   | 7       | 2        | 1      | Temp. start 21,2°C                 |
| 1112 | 35   | 6       | 1        | 3      | Rh start 65 %                      |
| 1114 | 25   | 5       | 3        | 2      |                                    |
| 1116 | 10   | 6       | 0        | 4      |                                    |
| 1117 | 7    | 7       | 2        | 1      | Temp. and Rh in the meteorological |
| 1119 | 5    | 4       | 3        | 3      | cage: 20°C and 59 %.               |
| 1120 | 3    | 4       | 0        | 6      |                                    |
| 1123 | 1,5  | 4       | 2        | 4      |                                    |
| 1126 | 1    | 5       | 2        | 3      |                                    |
| 1130 | 0,5  | 4       | 2        | 4      |                                    |

Ten moths were used in the experiment.

5 *A.exclamationis*  
 1 *S.pallens*  
 1 *P.strigilis*  
 1 *E.lucipara*  
 1 *H.lithargyria*  
 1 *P.persicaria*

Out of these *S.pallens* and *P.persicaria* never started.





Table 33

## DIEL OVIPOSITIONAL ACTIVITY

| species                     | Night | 22-23 | 23-24 | 24-01 | 01-02 | 02-03 | sum  |
|-----------------------------|-------|-------|-------|-------|-------|-------|------|
| A.exclamationis             | 28.6  | 3     |       |       |       |       | 3    |
| A.exclamationis             | 28.6  | 42    |       |       |       |       | 42   |
| A.exclamationis             | 28.6  | 13    |       |       |       |       | 13   |
| A.exclamationis             | 28.6  |       | 39    |       |       |       | 39   |
| A.exclamationis             | 20.6  |       | 5     |       |       |       | 5    |
| A.exclamationis             | 1.7   | 71    | 143   |       |       |       | 214  |
| A.exclamationis             | 1.7   | 5     | 63    |       |       |       | 68   |
| A.exclamationis             | 1.7   |       |       |       | 132   | 51    | 183  |
| A.exclamationis             | 1.7   | 21    | 87    |       |       |       | 108  |
| A.segetum                   | 1.7   | 9     |       |       |       |       | 9    |
| P.oleracea                  | 1.7   | 93    | 17    |       |       |       | 110  |
| A.exclamationis             | 2.7   | 74    |       |       |       |       | 74   |
| A.exclamationis             | 2.7   | 67    | 13    |       |       |       | 80   |
| A.exclamationis             | 2.7   | 134   |       |       |       |       | 134  |
| A.exclamationis             | 2.7   | 98    | 47    |       |       |       | 145  |
| A.exclamationis             | 2.7   |       | 13    | 9     |       |       | 22   |
| A.exclamationis             | 2.7   |       | 23    |       |       |       | 23   |
| A.exclamationis             | 3.7   | 11    | 37    |       |       |       | 48   |
| A.exclamationis             | 3.7   |       |       | 11    |       |       | 11   |
| A.exclamationis             | 3.7   | 27    | 11    |       |       |       | 38   |
| A.exclamationis             | 4.7   | 58    |       |       |       |       | 58   |
| A.exclamationis             | 4.7   |       | 69    |       |       |       | 69   |
| A.exclamationis             | 4.7   |       |       |       | 143   |       | 143  |
| A.exclamationis             | 4.7   |       | 16    |       |       |       | 16   |
| A.segetum                   | 4.7   |       | 87    |       |       |       | 87   |
| R.plecta                    | 4.7   |       |       |       | 38    |       | 38   |
| A.exclamationis             | 5.7   |       |       |       |       | 4     | 4    |
| A.exclamationis             | 5.7   |       | 40    |       |       |       | 40   |
| A.exclamationis             | 5.7   |       | 18    |       |       |       | 18   |
| A.exclamationis             | 5.7   |       | 81    | 3     |       |       | 84   |
| A.exclamationis             | 6.7   | 7     | 52    |       |       |       | 59   |
| A.exclamationis             | 6.7   |       |       |       | 62    |       | 62   |
| A.exclamationis             | 6.7   |       |       |       | 4     | 7     | 11   |
| A.exclamationis             | 7.7   | 47    |       |       |       |       | 47   |
| A.exclamationis             | 7.7   | 15    | 41    | 15    | 8     | 9     | 88   |
| A.exclamationis             | 7.7   |       |       | 4     | 11    |       | 15   |
| A.exclamationis             | 7.7   |       |       |       | 9     | 14    | 23   |
| A.exclamationis             | 7.7   |       | 88    |       |       |       | 88   |
| A.exclamationis             | 7.7   | 9     | 32    |       |       |       | 41   |
| A.exclamationis             | 7.7   | 15    | 38    | 6     |       |       | 59   |
| Sum                         |       | 819   | 1060  | 48    | 407   | 85    | 2419 |
| Mean                        |       | 20.5  | 26.5  | 1.2   | 10.2  | 2.1   | 60.5 |
| % of total no. of eggs      |       | 33.9  | 43.8  | 2.0   | 16.8  | 3.5   | 100  |
| No. of egg-laying occasions |       | 20    | 23    | 6     | 8     | 5     | 40   |

Egg-laying occasions: Sign. of diff.

|             |                  |                    |
|-------------|------------------|--------------------|
| 2200 - 2300 | $\chi_2 = 0.56$  | $0.50 > P > 0.30$  |
| 2300 - 2400 |                  |                    |
| 2300 - 2400 | $\chi_2 = 9.96$  | $0.01 > P > 0.001$ |
| 2400 - 0100 |                  |                    |
| 2200 - 0100 | $\chi_2 = 16.06$ | $P < 0.001$        |
| 2400 - 0300 |                  |                    |



Table 34

Death rate of newly captured moths after one day in relation to certain weather factors (several species)

| date | no. of<br>moths | % dead<br>moths | day mean<br>temp. | day max.<br>temp. | V.p.d.<br>day |
|------|-----------------|-----------------|-------------------|-------------------|---------------|
| 16.6 | 104             | 50              | 20.2              | 25.0              | 6.4           |
| 17.6 | 68              | 69              | 21.8              | 28.5              | 6.2           |
| 18.6 | 21              | 67              | 20.3              | 24.0              | 5.0           |
| 19.6 | 51              | 57              | 21.4              | 26.0              | 6.7           |
| 20.6 | 22              | 14              | 18.2              | 21.0              | 1.7           |
| 21.6 | 38              | 8               | 14.4              | 14.5              | 1.0           |
| 22.6 | 35              | 11              | 17.1              | 21.0              | 2.6           |
| 23.6 | 31              | 7               | 19.5              | 23.0              | 2.0           |
| 24.6 | 29              | 56              | 20.4              | 25.5              | 8.8           |
| 25.6 | 13              | 39              | 20.2              | 24.0              | 8.1           |
| 26.6 | 34              | 36              | 18.7              | 23.5              | 7.6           |
| 27.6 | 22              | 32              | 16.9              | 23.0              | 5.2           |
| 28.6 | 35              | 3               | 16.2              | 20.5              | 4.0           |
| 29.6 | 33              | 12              | 15.2              | 19.5              | 3.5           |
| 30.6 | 27              | 11              | 17.3              | 20.5              | 4.4           |
| 1.7  | 24              | 13              | 17.7              | 21.4              | 3.3           |
| 2.7  | 32              | 25              | 17.7              | 20.5              | 2.4           |
| 3.7  | 26              | 19              | 18.7              | 21.0              | 6.8           |
| 4.7  | 35              | 9               | 17.1              | 22.5              | 4.2           |
| 5.7  | 32              | 38              | 18.3              | 21.0              | 4.6           |
| mean | 35.6            | 28.8            | 18.4              | 22.3              | 4.7           |

Regression of death rate on:

1. Day mean temp.  $b = 9.35$ ,  $t = 7.3$ , d.f. 18,  $P < 0.001$
2. Day max.temp.  $b = 5.60$ ,  $t = 5.1$ , d.f. 18,  $P < 0.001$
3. Day V.p.d.  $b = 6.57$ ,  $t = 3.5$ , d.f. 18,  $0.005 > P > 0.001$



Table 35. INFLUENCE OF STRONG WINDS ON NOCTUIDS KEPT AT HIGH TEMPERATURE.

| Control group no wind |                  |                   |                      | Wind velocity 5-6 m/s |                  |                      |                            |
|-----------------------|------------------|-------------------|----------------------|-----------------------|------------------|----------------------|----------------------------|
| t°C in the cage       | Rh % in the cage | observed reaction |                      | t°C in the cage       | Rh % in the cage | observed reaction    | temp and Rh in the shadow. |
| 0900                  | 26.5             | 59                | 1 creeping           | 26.5                  | 59               | 4 flying, 2 creeping | 24.0 62                    |
| 0930                  | 25.5             | 54                |                      | 26.0                  | 54               | 2 creeping           | 24.5 59                    |
| 1000                  | 27.0             | 52                |                      | 27.5                  | 51               | 2 creeping           | 25.0 55                    |
| 1030                  | 27.0             | 50                |                      | 27.5                  | 49               | 3 creeping           | 25.0 53                    |
| 1100                  | 26.5             | 49                | 1 creeping           | 27.5                  | 49               | 4 flying, 2 creeping | 24.8 52                    |
| 1130                  | 25.5             | 48                | 1 creeping           | 27.0                  | 49               | 3 flying, 1 creeping | 25.0 50                    |
| 1200                  | 27.0             | 48                |                      | 27.5                  | 48               | 4 flying, 1 creeping | 25.2 49                    |
| 1230                  | 29.4             | 47                |                      | 29.0                  | 46               | 1 dead on the bottom | 26.0 50                    |
| 1300                  | 28.4             | 47                | 1 flying             | 28.9                  | 47               | 2 creeping           | 26.0 49                    |
| 1330                  | 28.0             | 49                |                      | 28.0                  | 48               |                      | 25.6 52                    |
| 1400                  | 26.5             | 48                | 1 creeping           | 27.4                  | 48               |                      | 25.6 50                    |
| 1430                  | 26.0             | 47                | 2 creeping           | 27.1                  | 47               | 1 flying             | 25.5 50                    |
| 1500                  | 26.2             | 47                | 1 flying, 1 creeping | 27.0                  | 47               |                      | 25.4 49                    |
| 1530                  | 25.7             | 48                | 1 creeping           | 26.4                  | 47               | 1 creeping           | 24.5 52                    |
| 1600                  | 25.0             | 51                |                      | 26.2                  | 49               |                      | 24.4 54                    |
| 1630                  | 24.5             | 53                |                      | 26.0                  | 52               |                      | 23.8 57                    |
| 1700                  | 22.3             | 56                |                      | 24.0                  | 55               |                      | 22.6 61                    |
| mean                  | 26.3             | 50.2              |                      | 27.1                  | 49.7             |                      | 24.9 53.2                  |

12 A. exclamationis in each group





Table 36 . Lifetime and activity of moths given food and water and moths not given food and water.

A.Lifetime

| date          | food and water     |                  | no food and no water |                  |
|---------------|--------------------|------------------|----------------------|------------------|
|               | no.of living moths | no.of dead moths | no. of living moths  | no.of dead moths |
| 10.5          | 12                 | 0                | 12                   | 0                |
| 11.5          | 12                 | 0                | 12                   | 0                |
| 12.5          | 12                 | 0                | 12                   | 0                |
| 13.5          | 12                 | 0                | 10                   | 2                |
| 14.5          | 7                  | 5                | 7                    | 3                |
| 15.5          | 6                  | 1                | 5                    | 2                |
| 16.5          | 5                  | 1                | 3                    | 2                |
| 17.5          | 5                  | 0                | 1                    | 2                |
| 18.5          | 4                  | 1                | 1                    | 0                |
| 19.5          | 4                  | 0                | 1                    | 0                |
| 20.5          | 4                  | 0                | 1                    | 0                |
| 21.5          | 4                  | 0                | 0                    | 1                |
| 22.5          | 4                  | 0                |                      |                  |
| 23.5          | 3                  | 1                |                      |                  |
| 24.5          | 2                  | 1                |                      |                  |
| 25.5          | 2                  | 0                |                      |                  |
| 26.5          | 2                  | 0                |                      |                  |
| 27.5          | 2                  | 0                |                      |                  |
| 28.5          | 2                  | 0                |                      |                  |
| 29.5          | 2                  | 0                |                      |                  |
| 30.5          | 1                  | 1                |                      |                  |
| 31.5          | 1                  | 0                |                      |                  |
| 1.6           | 1                  | 0                |                      |                  |
| 2.6           | 1                  | 0                |                      |                  |
| 3.6           | 0                  | 1                |                      |                  |
| mean lifetime | 9.2                |                  | 5.5                  |                  |

B.Activity

| a.m.    | No.of active moths |         |       |     |  | no food and no water |      |      |     |
|---------|--------------------|---------|-------|-----|--|----------------------|------|------|-----|
|         | food and water     |         |       |     |  |                      |      |      |     |
|         | 10.5               | 11.5    | 12.5  | sum |  | 10.5                 | 11.5 | 12.5 | sum |
| 20.45   | (1)                | 0       | 1 (4) | 1   |  | 0                    | 1    | 1    | 2   |
| 21.00   | 1 (2)              | 6 (4)   | 1 (9) | 8   |  | 1                    | 2    | 6    | 9   |
| 21.15   | 3 (2)              | 5 (4)   | 2 (6) | 10  |  | 6                    | 4    | 4    | 14  |
| 21.30   | 4 (3)              | 3 (7)   | 2 (6) | 9   |  | 3                    | 0    | 1    | 4   |
| 21.45   | 5 (3)              | 4 (2)   | 0 (7) | 9   |  | 3                    | 0    | 0    | 3   |
| 22.00   | 4 (4)              | 5 (5)   | 1 (5) | 10  |  | 2                    | 0    | 0    | 2   |
| 22.15   | 9                  | 7       | 2 (4) | 18  |  | 3                    | 1    | 0    | 4   |
| 22.30   | 7                  | 9       | 3 (5) | 19  |  | 2                    | 1    | 0    | 3   |
| 33 (15) | 39 (22)            | 12 (46) | 84    | 20  |  | 9                    | 12   | 41   |     |

Twelve *M.incerta* (males) caught on the 9.5 in four different traps were used in each group.

(4) = moths eating.



Table 37 HATCH OF ADULT MOTHS 1969 AND 1970 FROM EGGS LAID IN 1969

| Species                | no.of<br>eggs<br>laid | date of<br>laying | date of<br>app.of<br>adult | hatch<br>in %<br>of eggs<br>laid | no.of<br>males | no.of<br>females | total<br>hatch<br>of<br>adults | per cent<br>females<br>in the<br>hatch |
|------------------------|-----------------------|-------------------|----------------------------|----------------------------------|----------------|------------------|--------------------------------|----------------------------------------|
| B.brassicae            | 23                    | 27.6.69           | 4.9.69                     | 30                               | 1              | 6                | 7 <sup>1)</sup>                | 86                                     |
|                        |                       | 27.6.69           | 15.6.70                    | 61                               | 8              | 6                | 14 <sup>1)</sup>               | 43                                     |
| 1)from the same female |                       |                   |                            | 91                               | 9              | 12               | 21                             | 52                                     |
| M.stabilis             | 41                    | 16.5.69           | 20.4.70                    | 37                               | 6              | 9                | 15                             | 60                                     |
| R.c-nigrum             | 64                    | 6.7.69            | 6.9.69                     | 88                               | 30             | 26               | 56                             | 46                                     |
| R.plecta               | 138                   | 4.6.69            | 5.6.70                     | 46                               | 36             | 28               | 46                             | 44                                     |
| R.rubi <sup>2)</sup>   | ?                     | ?                 | 9.8.69                     | ?                                | 10             | 13               | 23                             | 57                                     |
|                        | (266)                 |                   |                            | (66)                             | 91             | 88               | 179                            | 52                                     |

<sup>2)</sup> No controlled breeding of R.rubi had been performed. The eggs probably were brought into the cages with the food.





## LIST OF SPECIES

| Species                          | 1968 |     |      | 1969 |      |      | total | flight period |    |    |    |    |    |     |
|----------------------------------|------|-----|------|------|------|------|-------|---------------|----|----|----|----|----|-----|
|                                  | ♂    | ♀   | sum  | ♂    | ♀    | sum  |       | 14            | 15 | 16 | 17 | 18 | 19 | 111 |
| 1. <i>Acronycta leporina</i>     | 1    | 2   | 3    | 3    | 4    | 7    | 10    |               |    |    |    |    |    |     |
| 2. <i>Acronycta aceris</i>       | 1    | 1   | 2    | 4    | 2    | 6    | 8     |               |    |    |    |    |    |     |
| 3. <i>Acronycta megacephala</i>  | 1    | 2   | 3    | 9    | 2    | 11   | 20    |               |    |    |    |    |    |     |
| 4. <i>Acronycta psi</i>          | 49   | 10  | 59   | 39   | 13   | 52   | 111   |               |    |    |    |    |    |     |
| 5. <i>Acronycta menyanthidis</i> | 1    | 0   | 1    | 0    | 0    | 0    | 1     |               |    |    |    |    |    |     |
| 6. <i>Acronycta rumisis</i>      | 1    | 0   | 1    | 3    | 1    | 4    | 5     |               |    |    |    |    |    |     |
| 7. <i>Craniophora ligustri</i>   | 27   | 11  | 38   | 13   | 19   | 32   | 70    |               |    |    |    |    |    |     |
| 8. <i>Euxoa obelisca</i>         | 62   | 22  | 84   | 91   | 27   | 118  | 202   |               |    |    |    |    |    |     |
| 9. <i>Euxoa nigricans</i>        | 145  | 52  | 197  | 61   | 46   | 107  | 304   |               |    |    |    |    |    |     |
| 10. <i>Euxoa tritici</i>         | 95   | 42  | 137  | 30   | 14   | 44   | 181   |               |    |    |    |    |    |     |
| 11. <i>Agrotis ypsilon</i>       | 2    | 3   | 5    | 0    | 0    | 0    | 5     |               |    |    |    |    |    |     |
| 12. <i>Agrotis segetum</i>       | 739  | 167 | 906  | 558  | 102  | 660  | 1566  |               |    |    |    |    |    |     |
| 13. <i>Agrotis corticea</i>      | 214  | 48  | 262  | 214  | 41   | 255  | 469   |               |    |    |    |    |    |     |
| 14. <i>Agrotis vestigialis</i>   | 0    | 0   | 0    | 0    | 1    | 1    | 1     |               |    |    |    |    |    |     |
| 15. <i>Agrotis exclamatonis</i>  | 2376 | 665 | 3041 | 3879 | 1038 | 4917 | 7958  |               |    |    |    |    |    |     |
| 16. <i>Rhyacia simulans</i>      | 40   | 17  | 57   | 13   | 17   | 30   | 87    |               |    |    |    |    |    |     |
| 17. <i>Rhyacia porphyrea</i>     | 0    | 0   | 0    | 2    | 1    | 3    | 3     |               |    |    |    |    |    |     |
| 18. <i>Rhyacia mendica</i>       | 3    | 2   | 5    | 1    | 1    | 2    | 7     |               |    |    |    |    |    |     |
| 19. <i>Rhyacia brunnea</i>       | 4    | 1   | 5    | 3    | 1    | 4    | 9     |               |    |    |    |    |    |     |
| 20. <i>Rhyacia baja</i>          | 1    | 0   | 1    | 1    | 0    | 1    | 2     |               |    |    |    |    |    |     |
| 21. <i>Rhyacia rubi</i>          | 964  | 334 | 1298 | 1512 | 659  | 2171 | 3469  |               |    |    |    |    |    |     |
| 22. <i>Rhyacia c-nigrum</i>      | 1665 | 440 | 2105 | 1958 | 818  | 2776 | 4881  |               |    |    |    |    |    |     |
| 23. <i>Rhyacia triangulum</i>    | 132  | 25  | 157  | 101  | 38   | 139  | 296   |               |    |    |    |    |    |     |
| 24. <i>Rhyacia plecta</i>        | 101  | 24  | 125  | 222  | 42   | 264  | 389   |               |    |    |    |    |    |     |
| 25. <i>Rhyacia umbrosa</i>       | 112  | 29  | 141  | 120  | 23   | 143  | 284   |               |    |    |    |    |    |     |
| 26. <i>Rhyacia xanthographa</i>  | 253  | 36  | 289  | 358  | 49   | 407  | 696   |               |    |    |    |    |    |     |
| 27. <i>Rhyacia putris</i>        | 235  | 41  | 276  | 364  | 43   | 407  | 683   |               |    |    |    |    |    |     |
| 28. <i>Rhyacia augur</i>         | 14   | 1   | 15   | 15   | 4    | 19   | 34    |               |    |    |    |    |    |     |
| 29. <i>Amphitrota ravida</i>     | 151  | 83  | 234  | 60   | 29   | 89   | 323   |               |    |    |    |    |    |     |
| 30. <i>Eurois prasina</i>        | 2    | 0   | 2    | 1    | 0    | 1    | 3     |               |    |    |    |    |    |     |
| 31. <i>Eurois oculata</i>        | 1    | 0   | 1    | 0    | 0    | 0    | 1     |               |    |    |    |    |    |     |
| 32. <i>Cerastis rubricosa</i>    | 1    | 0   | 1    | 0    | 0    | 0    | 1     |               |    |    |    |    |    |     |
| 33. <i>Orthosia caecimacula</i>  | 0    | 0   | 0    | 1    | 0    | 1    | 2     |               |    |    |    |    |    |     |
| 34. <i>Naenia typica</i>         | 1    | 0   | 1    | 1    | 0    | 1    | 2     |               |    |    |    |    |    |     |
| 35. <i>Triphaena orbona</i>      | 31   | 4   | 35   | 23   | 5    | 28   | 63    |               |    |    |    |    |    |     |
| 36. <i>Triphaena subsequa</i>    | 16   | 6   | 22   | 7    | 0    | 7    | 29    |               |    |    |    |    |    |     |
| 37. <i>Triphaena pronuba</i>     | 970  | 194 | 1164 | 521  | 111  | 632  | 1796  |               |    |    |    |    |    |     |
| 38. <i>Triphaena fimbria</i>     | 2    | 1   | 3    | 3    | 5    | 8    | 11    |               |    |    |    |    |    |     |
| 39. <i>Triphaena janthina</i>    | 17   | 4   | 21   | 17   | 5    | 22   | 43    |               |    |    |    |    |    |     |
| 40. <i>Barathra brassicae</i>    | 19   | 6   | 25   | 42   | 11   | 53   | 78    |               |    |    |    |    |    |     |



Table 38 (cont'd)

| Species                 | 1968 |    | sum | 1969 |     | sum | total | flight period |    |    |    |    |    |      |      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| 41.Scotogramma trifolii | 149  | 37 | 186 | 450  | 202 | 652 | 838   |               |    |    |    |    |    |      |      |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |















Table 38 (cont'd)

| Species                         | 1968  |      | 1969  | sum  |       | total | flight period |    |    |    |    |    |     |
|---------------------------------|-------|------|-------|------|-------|-------|---------------|----|----|----|----|----|-----|
|                                 | ♂     | ♀    | ♂     | ♀    | sum   |       | 14            | 15 | 16 | 17 | 18 | 19 | 111 |
| 161. Eustrotia uncula           | 0     | 1    | 0     | 1    | 1     | 2     |               |    |    |    |    |    |     |
| 162. Earias chlorana            | 15    | 7    | 6     | 0    | 22    | 28    |               |    |    |    |    |    |     |
| 163. Hylophila prasinana        | 2     | 7    | 3     | 4    | 9     | 16    |               |    |    |    |    |    |     |
| 164. Catocala nupta             | 0     | 0    | 2     | 0    | 0     | 2     |               |    |    |    |    |    |     |
| 165. Syngnapha interrogationis  | 0     | 1    | 0     | 0    | 1     | 1     |               |    |    |    |    |    |     |
| 166. Phytometra festucae        | 30    | 11   | 27    | 8    | 41    | 76    |               |    |    |    |    |    |     |
| 167. Phytometra bractea         | 0     | 0    | 1     | 0    | 0     | 1     |               |    |    |    |    |    |     |
| 168. Phytometra chrysitis       | 84    | 17   | 100   | 10   | 101   | 211   |               |    |    |    |    |    |     |
| 169. Phytometra iota            | 27    | 6    | 34    | 6    | 33    | 73    |               |    |    |    |    |    |     |
| 170. Phytometra pulchrina       | 2     | 0    | 0     | 0    | 2     | 2     |               |    |    |    |    |    |     |
| 171. Phytometra confusa         | 1     | 0    | 3     | 2    | 1     | 6     |               |    |    |    |    |    |     |
| 172. Plusia gamma               | 2170  | 1439 | 749   | 415  | 3609  | 4773  |               |    |    |    |    |    |     |
| 173. Polychrysia moneta         | 5     | 4    | 14    | 7    | 9     | 30    |               |    |    |    |    |    |     |
| 174. Abrostola triplacia        | 2     | 0    | 1     | 0    | 2     | 3     |               |    |    |    |    |    |     |
| 175. Abrostola tripartita       | 8     | 11   | 10    | 3    | 19    | 32    |               |    |    |    |    |    |     |
| 176. Scoliopteryx libatrix      | 1     | 2    | 2     | 2    | 3     | 7     |               |    |    |    |    |    |     |
| 177. Toxocampa pastinum         | 1     | 0    | 2     | 3    | 1     | 6     |               |    |    |    |    |    |     |
| 178. Laspeyria flexula          | 1     | 0    | 1     | 0    | 1     | 2     |               |    |    |    |    |    |     |
| 179. Rivula sericealis          | 1     | 1    | 11    | 3    | 2     | 16    |               |    |    |    |    |    |     |
| 180. Zanclognatha tarsinennalis | 40    | 8    | 10    | 2    | 48    | 60    |               |    |    |    |    |    |     |
| 181. Zanclognatha nemoralis     | 1     | 0    | 0     | 0    | 1     | 1     |               |    |    |    |    |    |     |
| 182. Hypena proboscidalis       | 37    | 8    | 44    | 12   | 45    | 101   |               |    |    |    |    |    |     |
| sum                             | 19431 | 5793 | 18205 | 5541 | 23746 | 48970 |               |    |    |    |    |    |     |
| undetermined                    | 175   | 64   | 124   | 28   | 152   | 391   |               |    |    |    |    |    |     |
| total sum                       | 19606 | 5857 | 18329 | 5569 | 23898 | 49361 |               |    |    |    |    |    |     |
| % of yearly catch               | 77.0  | 23.0 | 76.7  | 23.3 |       |       |               |    |    |    |    |    |     |
| % of total catch                |       |      |       |      | 48.4  |       |               |    |    |    |    |    |     |
|                                 |       |      |       |      | 51.6  |       |               |    |    |    |    |    |     |







## **APPENDIX II**

### **FIGURES**



THE CATCHING PLACE BUNKEFLOSTRAND

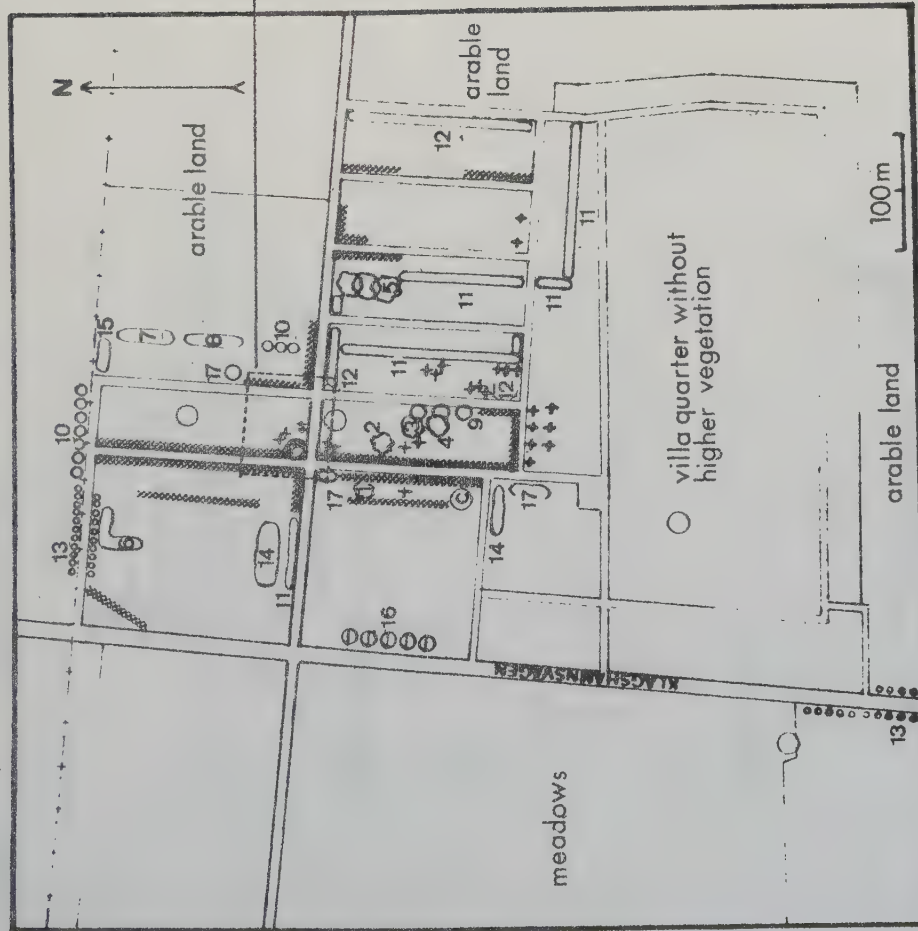


FIG.1

HIGHER VEGETATION

1. Sorbus aucuparea
2. Acer platanoides
3. Salix caprea
4. Tilia cordata
5. Ulmus glabra
6. Spirea arguta
7. Cytisus laburnum
8. Salix fragilis
9. Aesculus hippocastanum
10. Populus alba

● The light trap

11. Thuja occidentalis
12. Fagus sylvatica
13. Sorbus intermedia
14. Syringa vulgaris
15. Salix alba
16. Prunus armeniaca
17. Betula alba
- + Picea, Pinus and Larix spec.

Not marked: a great number of Prunus domestica, Pyrus communis and Pyrus malus

THE AREA AROUND THE LIGHT TRAP

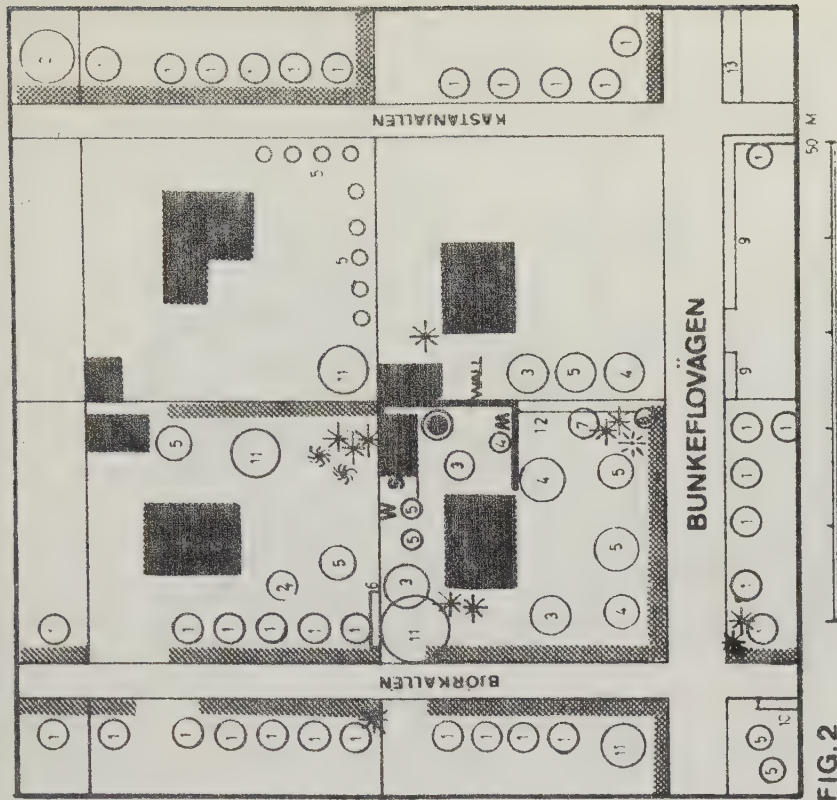


FIG.2

1. Betula alba

2. Aesculus hippocastanum

3. Prunus domestica

4. Pyrus communis

5. Pyrus malus

6. Syringa vulgaris

7. Prunus persicaria

8. Lonicera caprifolium

9. Ligustrum vulgare

10. Crataegus spec.

11. Prunus cerasus

12. Fagus sylvatica

13. Sorbus intermedia

14. Syringa vulgaris

15. Salix alba

16. Prunus armeniaca

17. Betula alba

+ Picea, Pinus and Larix spec.

11. Prunus cerasus

\* Abies and Picea spec.

\*\* Pinus silvestris

\* Larix spec.

● The light trap

■ Buildings

W=wind velocity experiments

S=flight start observations

M=meteorological cage

Hedges and bushes of Forsythia, Kolkwitzia, Ribes,

Spirea and Viburnum



FIG.3

THE LIGHT TRAP

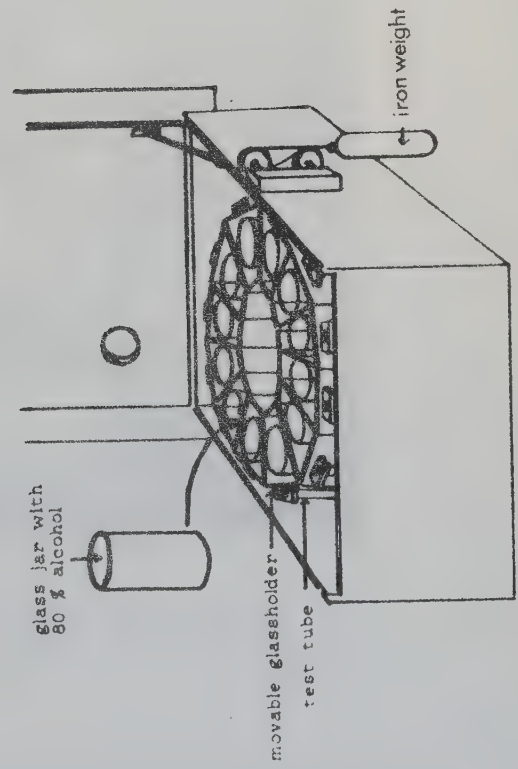
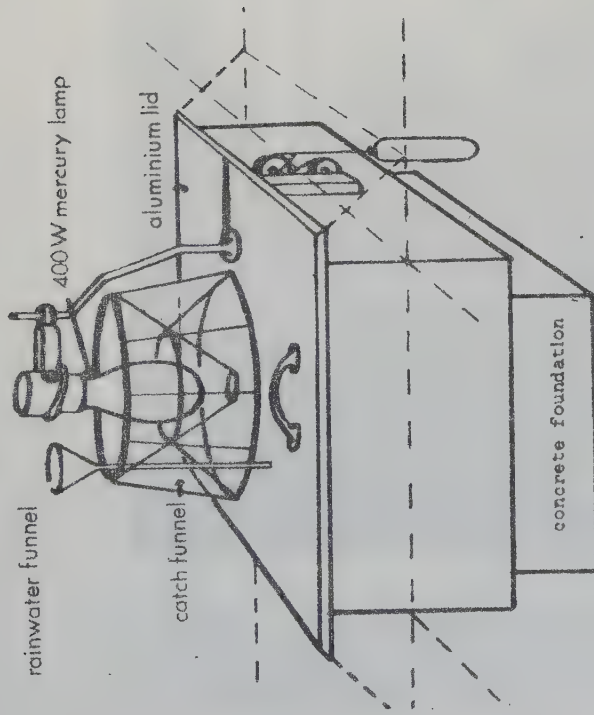
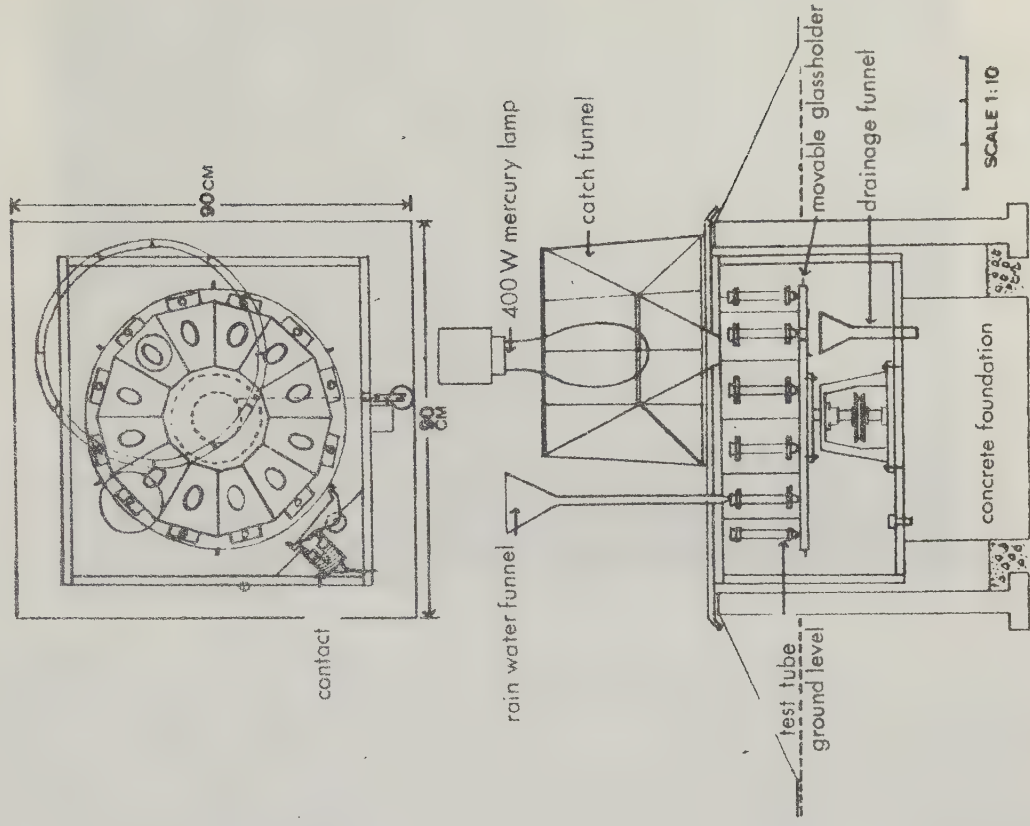


FIG.4

CONSTRUCTION DRAWING







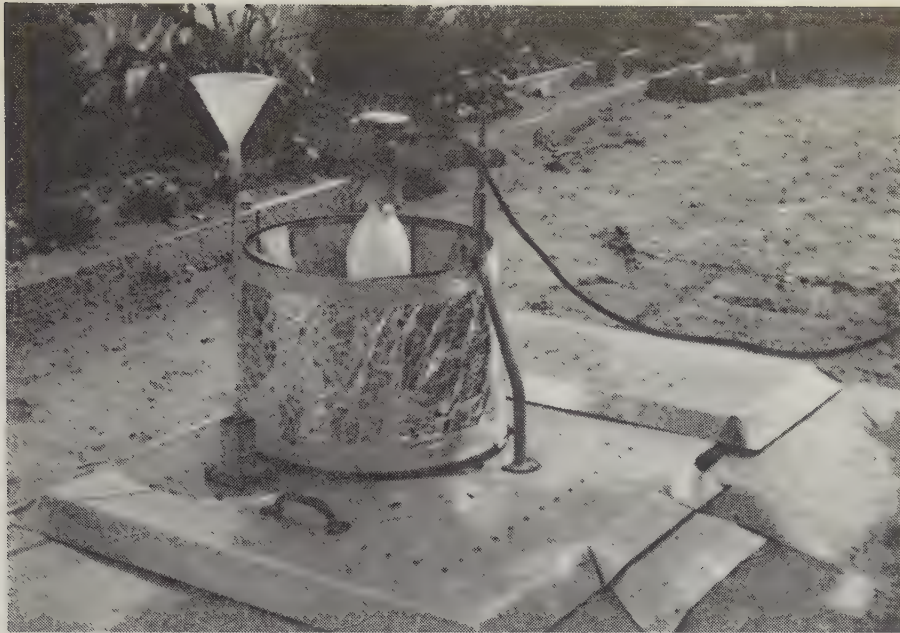


Fig.5. The light trap ready for catch. Only the catch funnel, the rainwater funnel, and the lamp are above ground level.



Fig.6. The light trap opened. The turntable with the partitions for jars and the test tubes for rainwater are visible.





Fig.7. A view of the catching area. In the background the cage for meteorological instruments and the wind measuring equipment. In the foreground the trap and the rain gauge.



Fig.8. The simulator for determination of the wind direction. A paper from the wind direction registration apparatus is put into the simulator.







FIG.9 BASIS FOR CALCULATION OF MEAN VALUES 1968 AND 1969

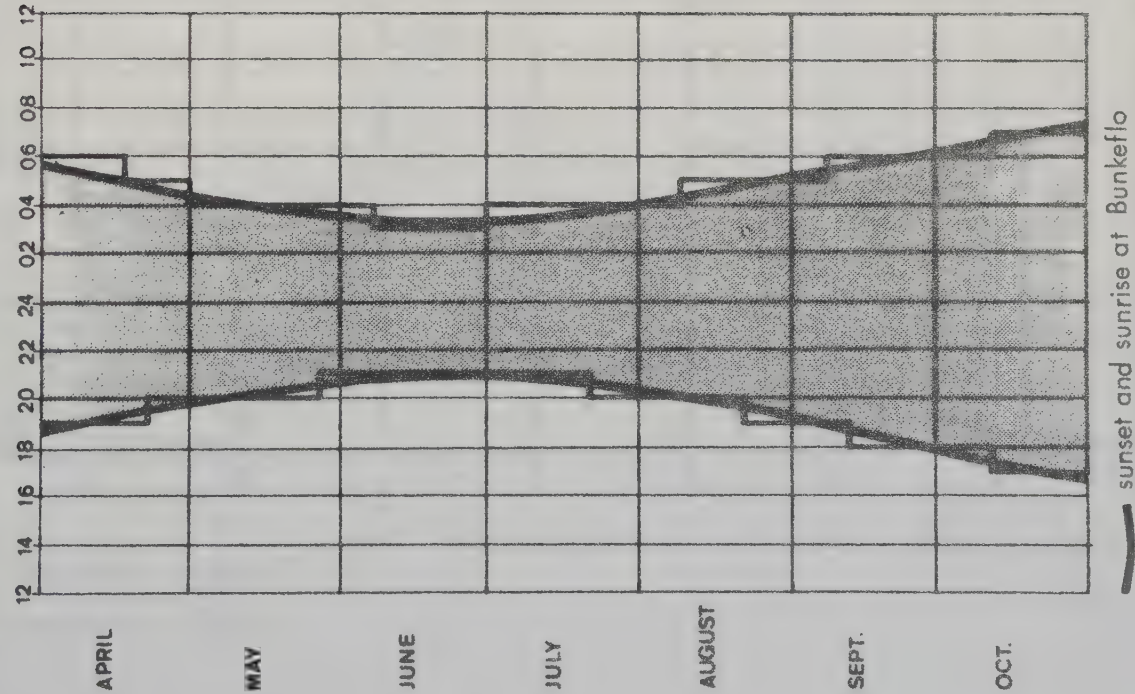


FIG.10 WIND REGISTRATION APPARATUS

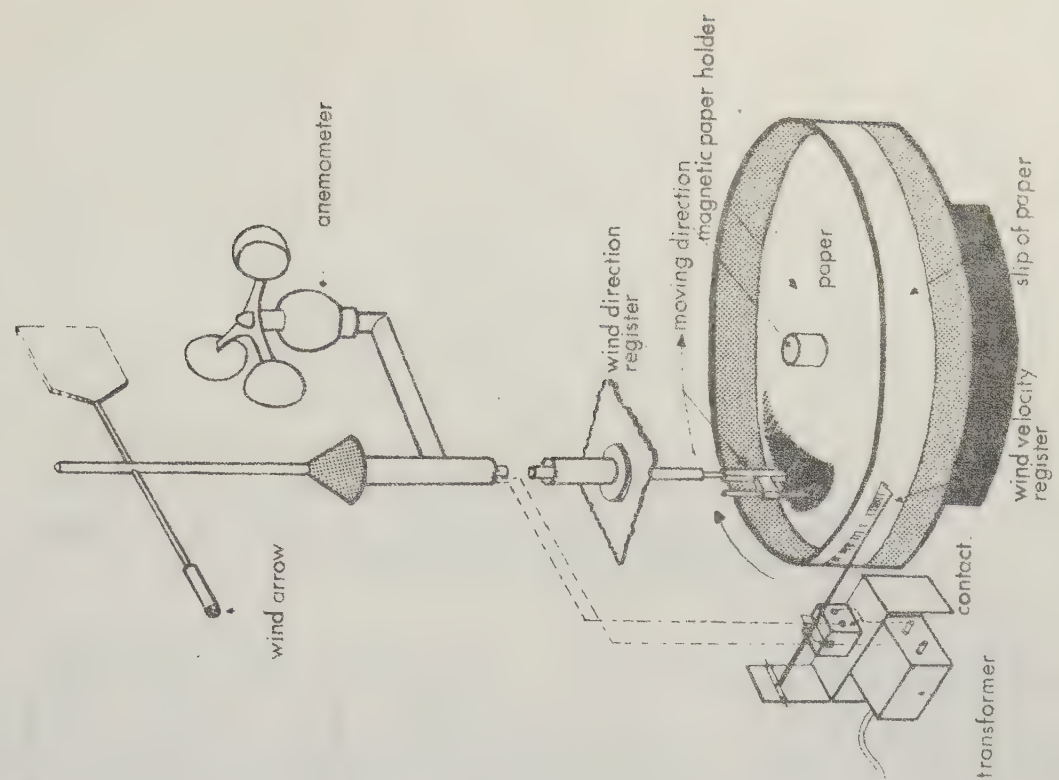




Fig.11 MONTHLY DISTRIBUTION OF CATCH  
ALL LEPIDOPTERA

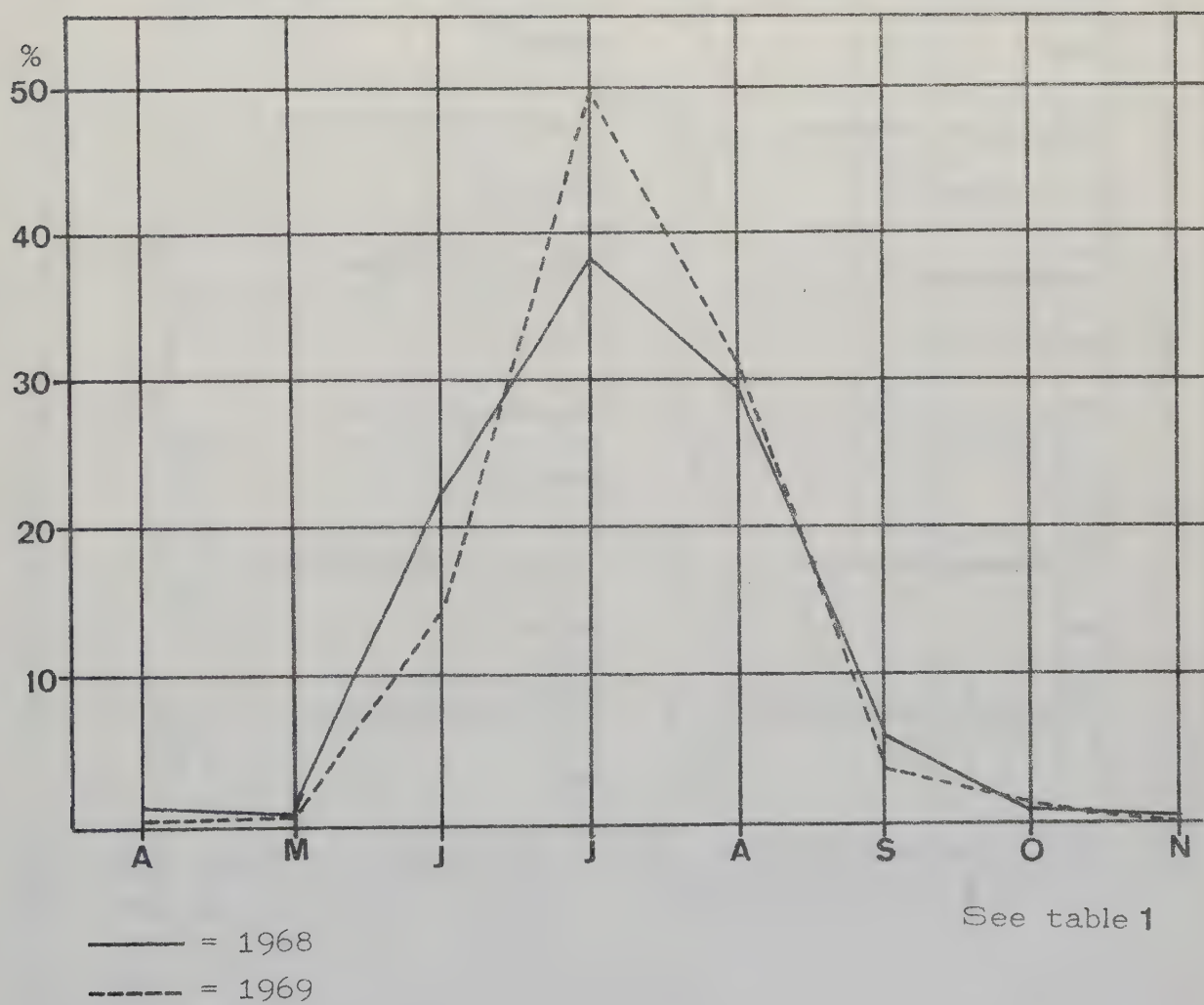




FIG.12

MONTHLY DISTRIBUTION OF CATCH OF DIFFERENT LEPIDOPTERA GROUPS

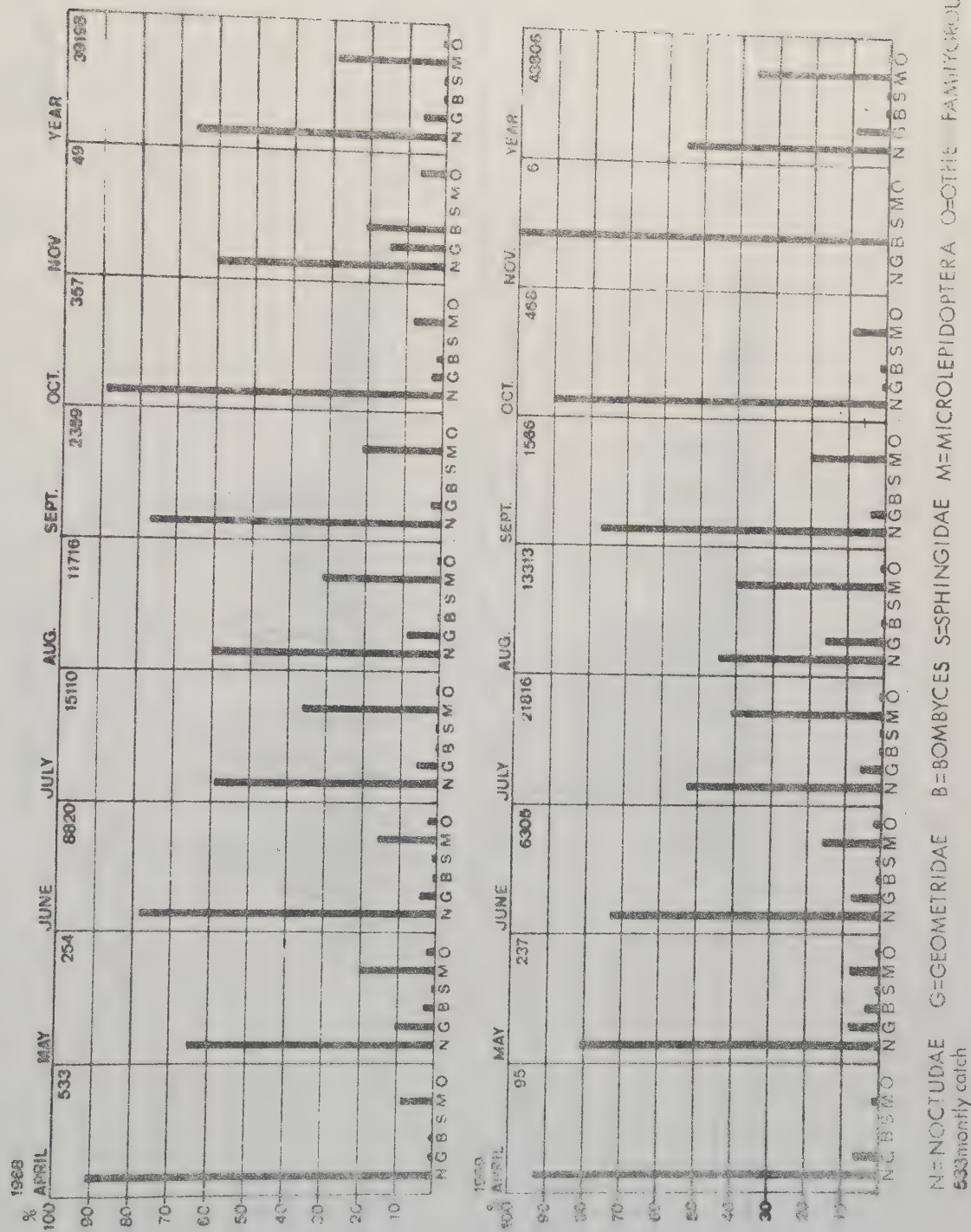






FIG.13

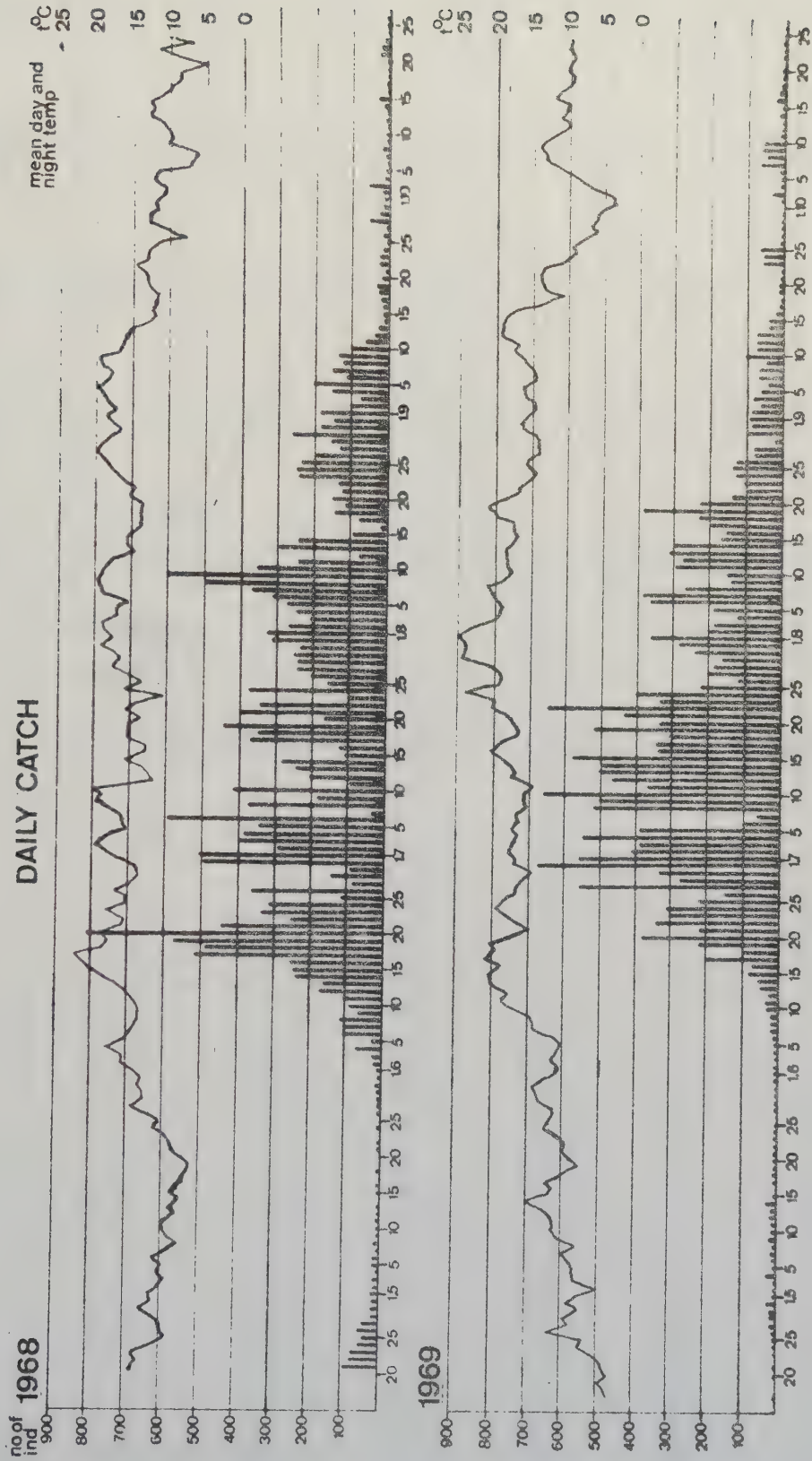




Fig.14 MONTHLY AVERAGE NUMBER OF SPECIES IN THE CATCH.

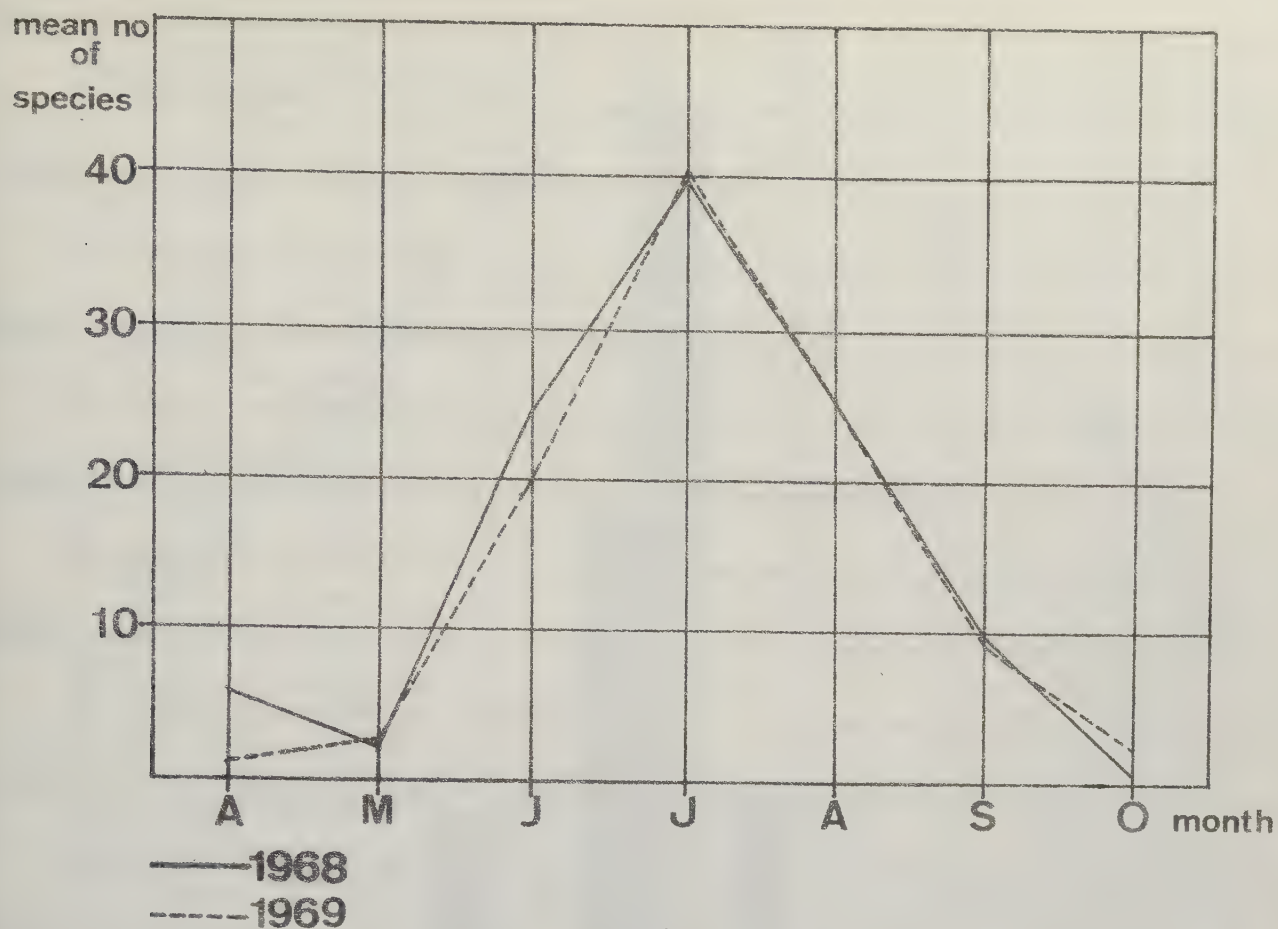


Fig.15 NUMBER OF SPECIES IN DIFFERENT SIZE-GROUPS.

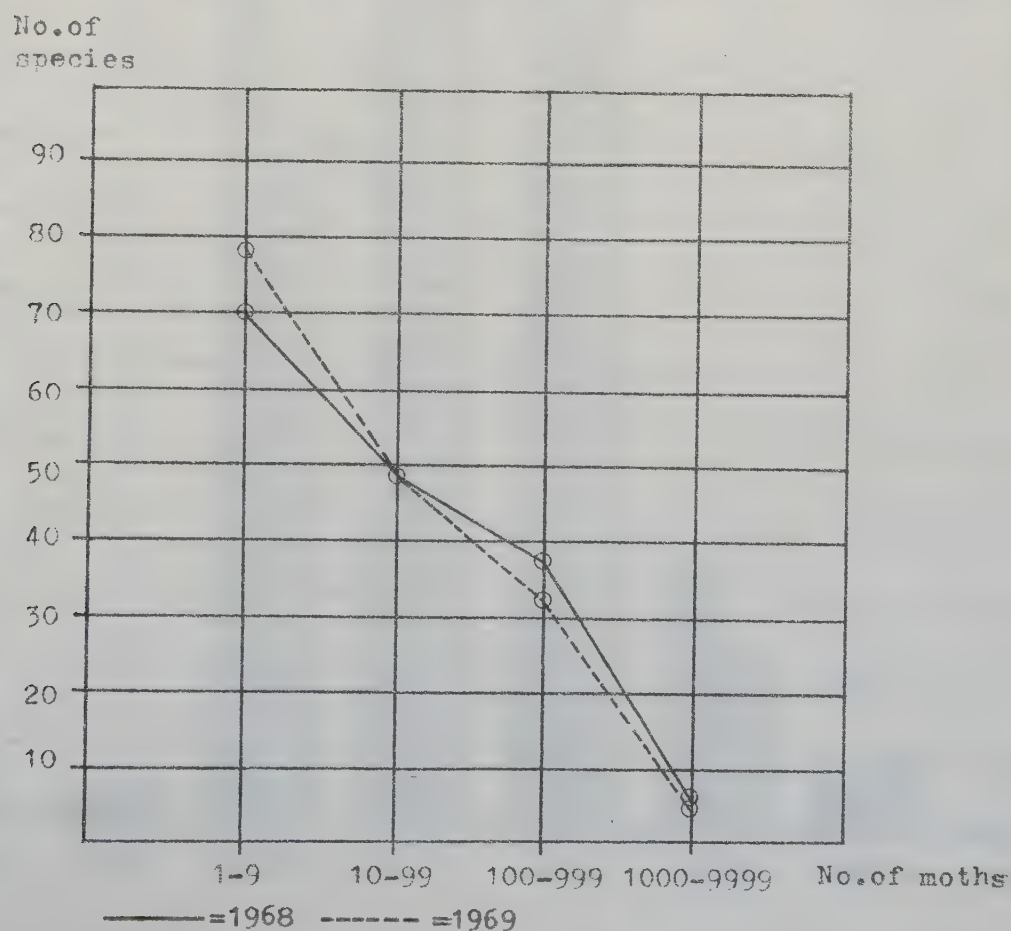






FIG.16

## MONTHLY CATCH; FAM. NOCTUIDAE

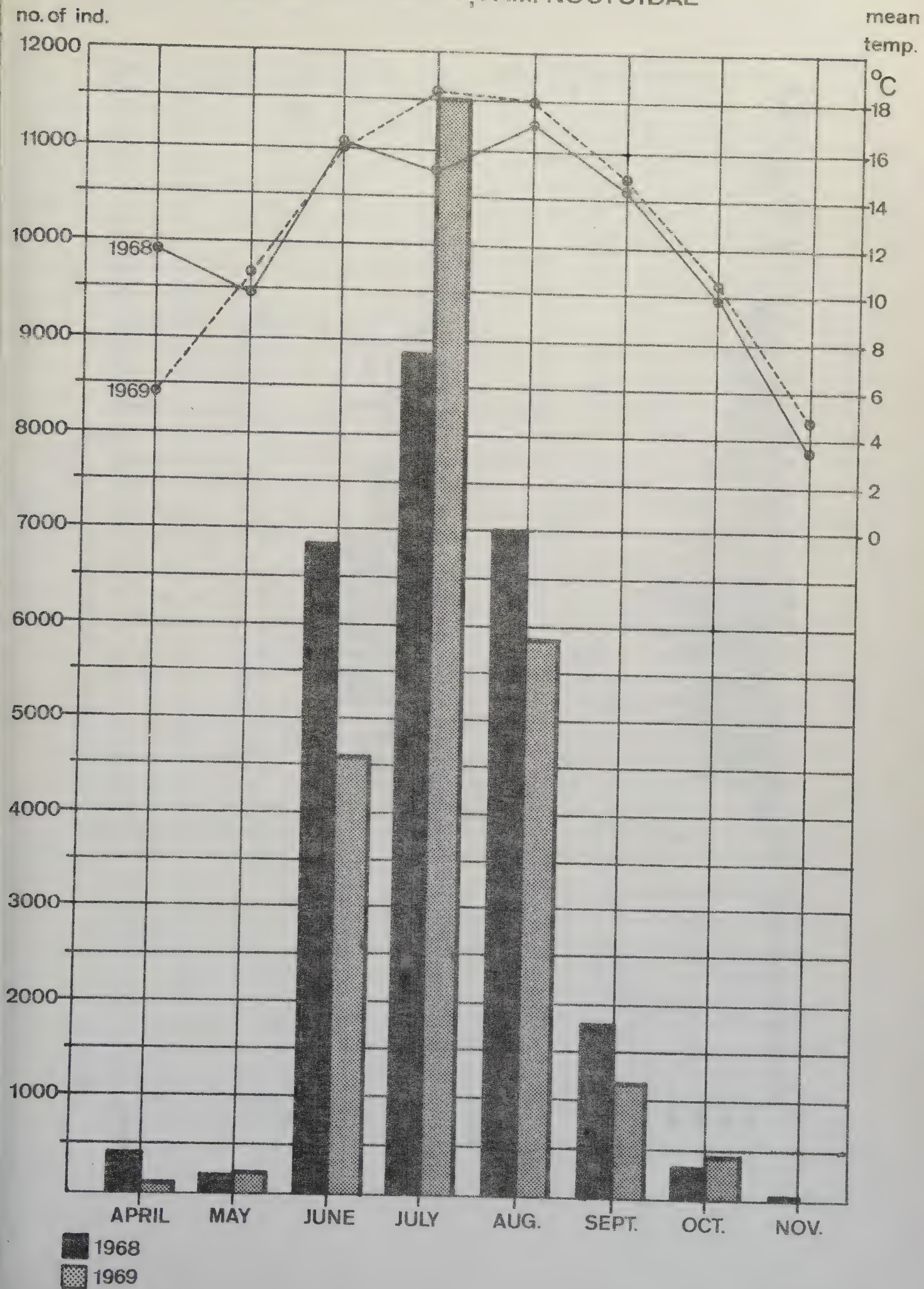






FIG.17

DAILY CATCH OF SPECIES

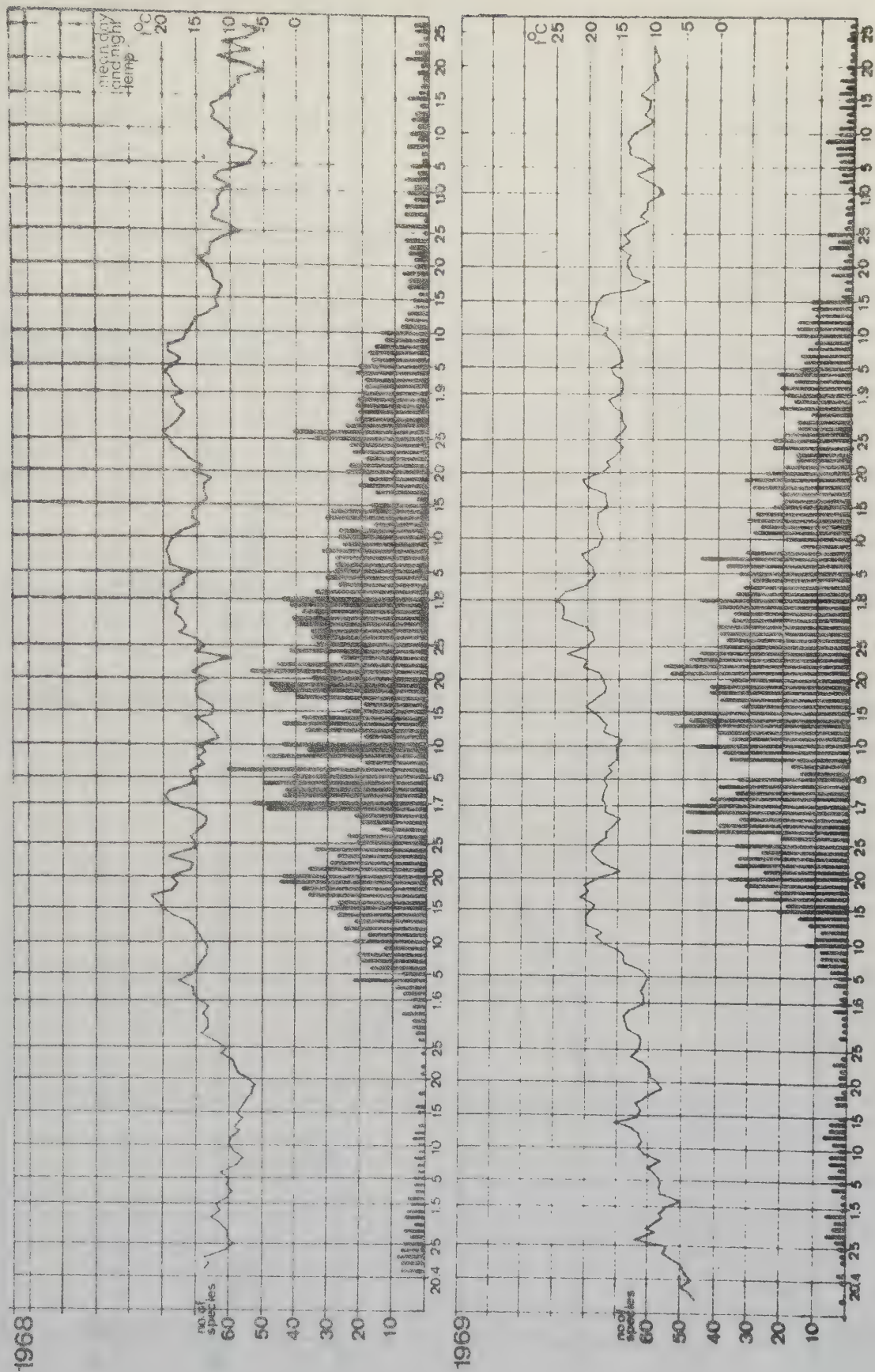




FIG.18.DISTRIBUTION OF CATCH OF MALES AND FEMALES ON MONTHS 1968

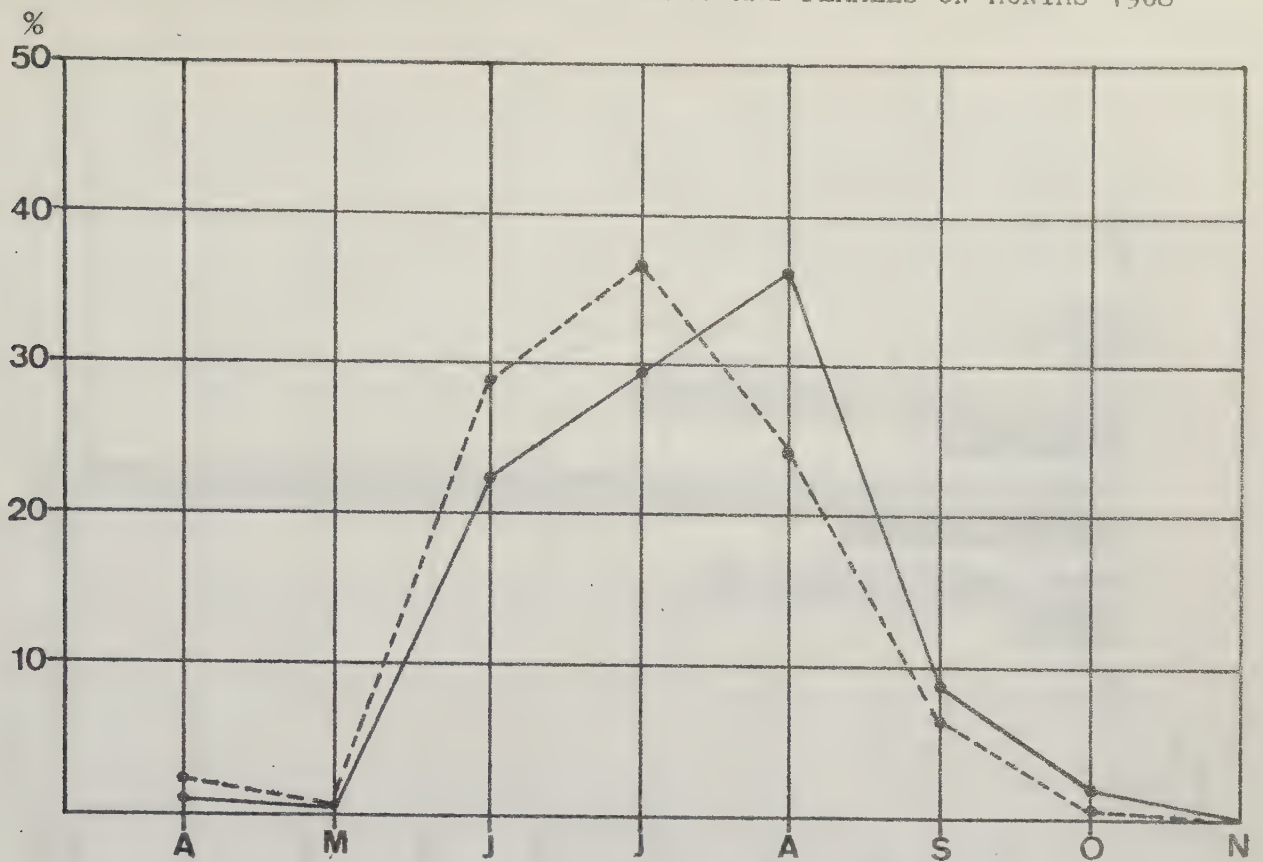
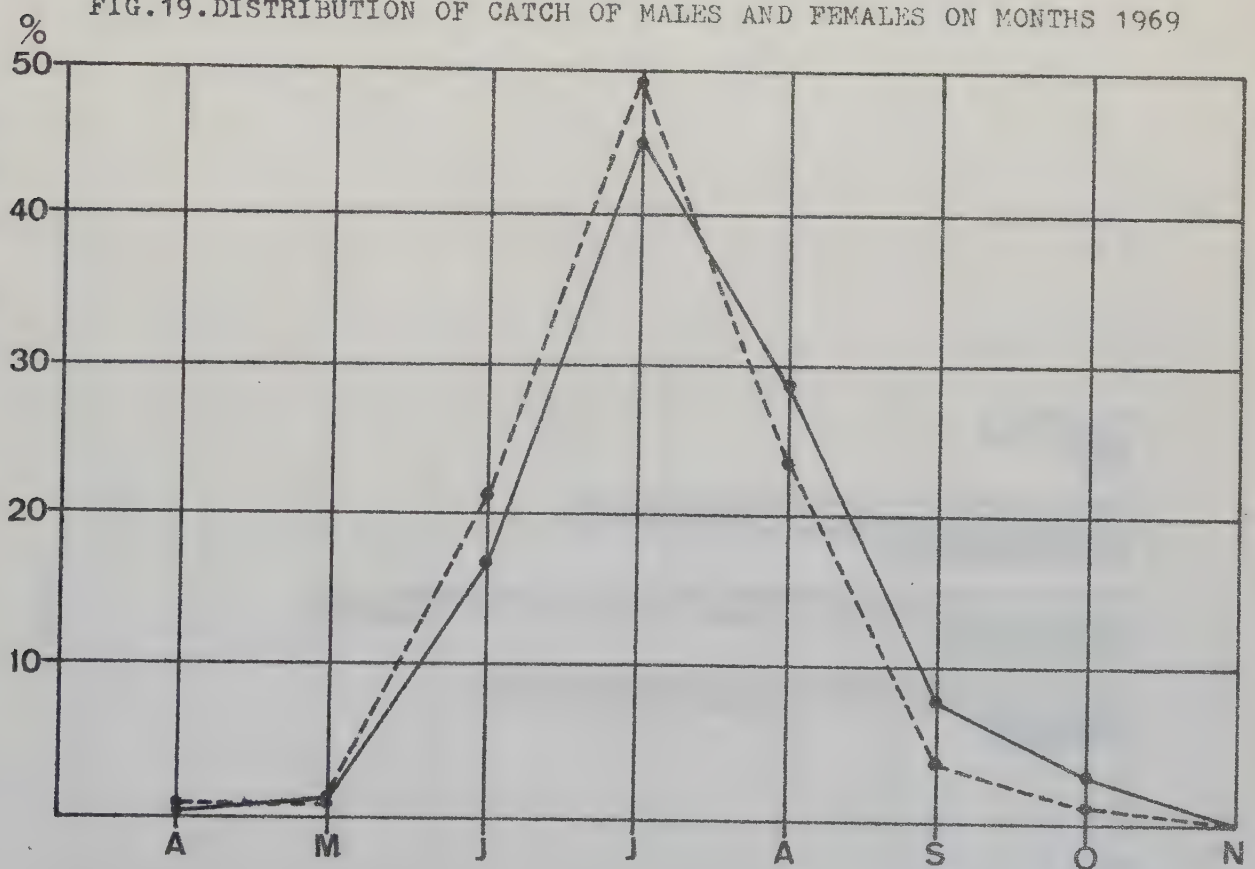


FIG.19.DISTRIBUTION OF CATCH OF MALES AND FEMALES ON MONTHS 1969



———— = females      - - - - - males





FIG.20 MONTHLY DISTRIBUTION OF CATCH

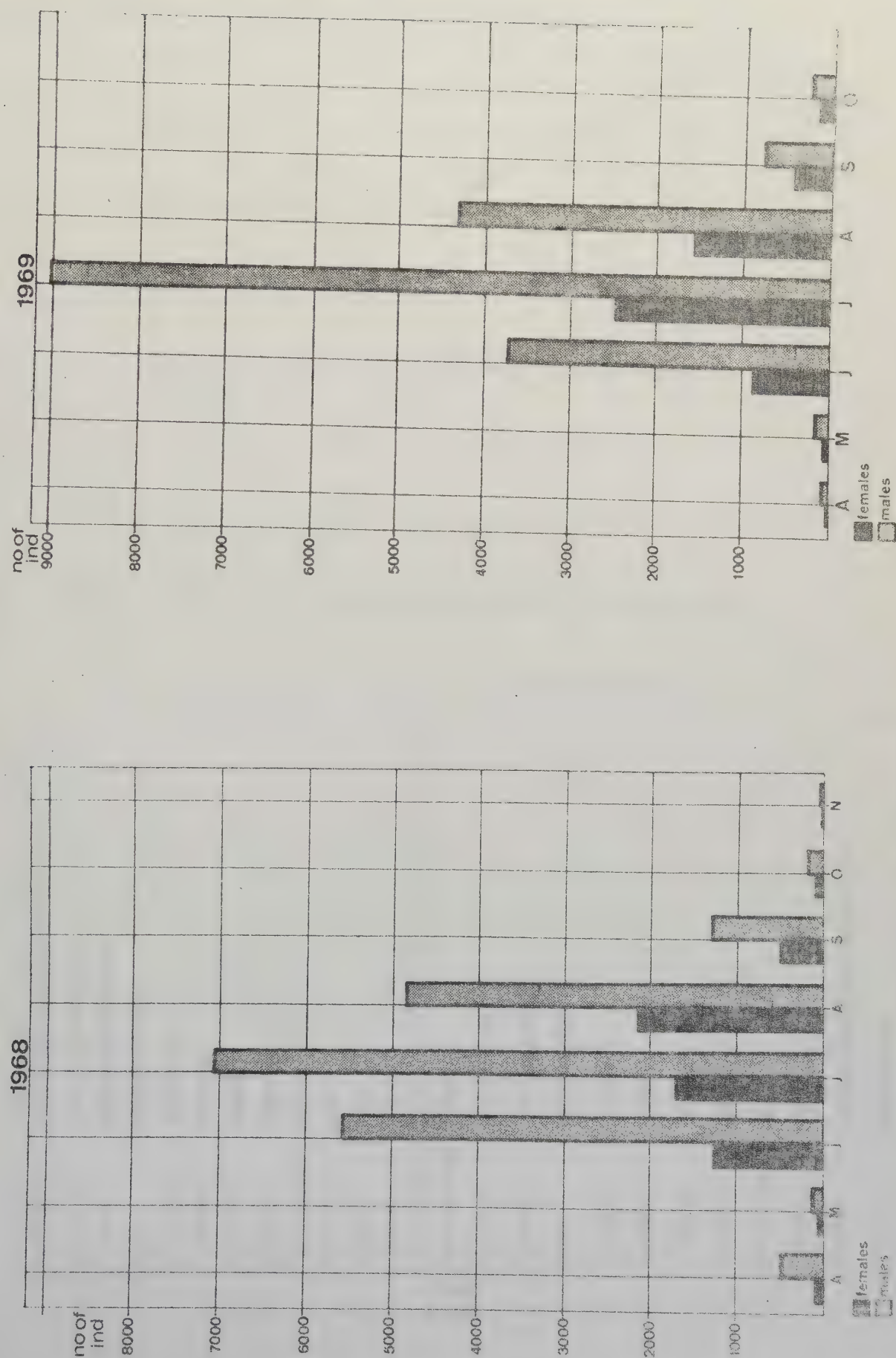




FIG.21

RELATIVE NUMBER OF FEMALES IN THE CATCH

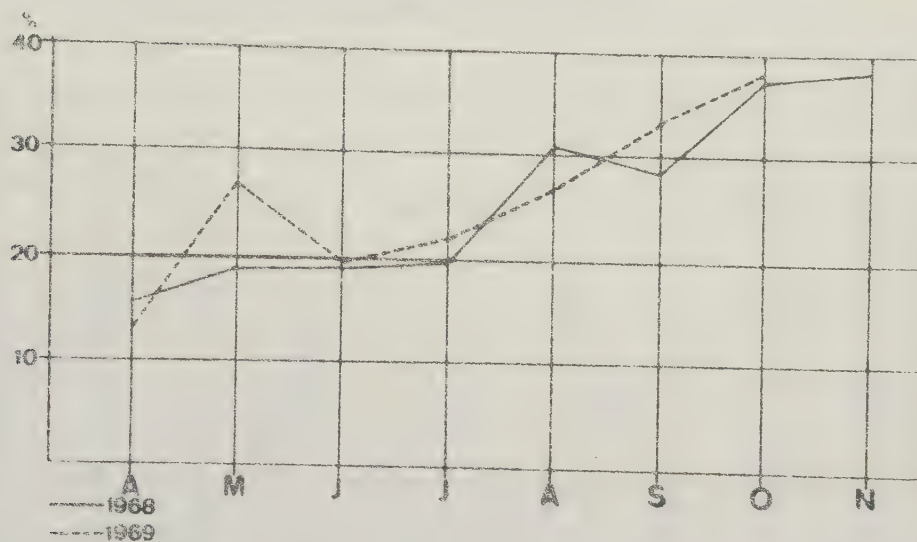


FIG.22

THE TWELVE MOST ABUNDANT SPECIES IN THE CATCH

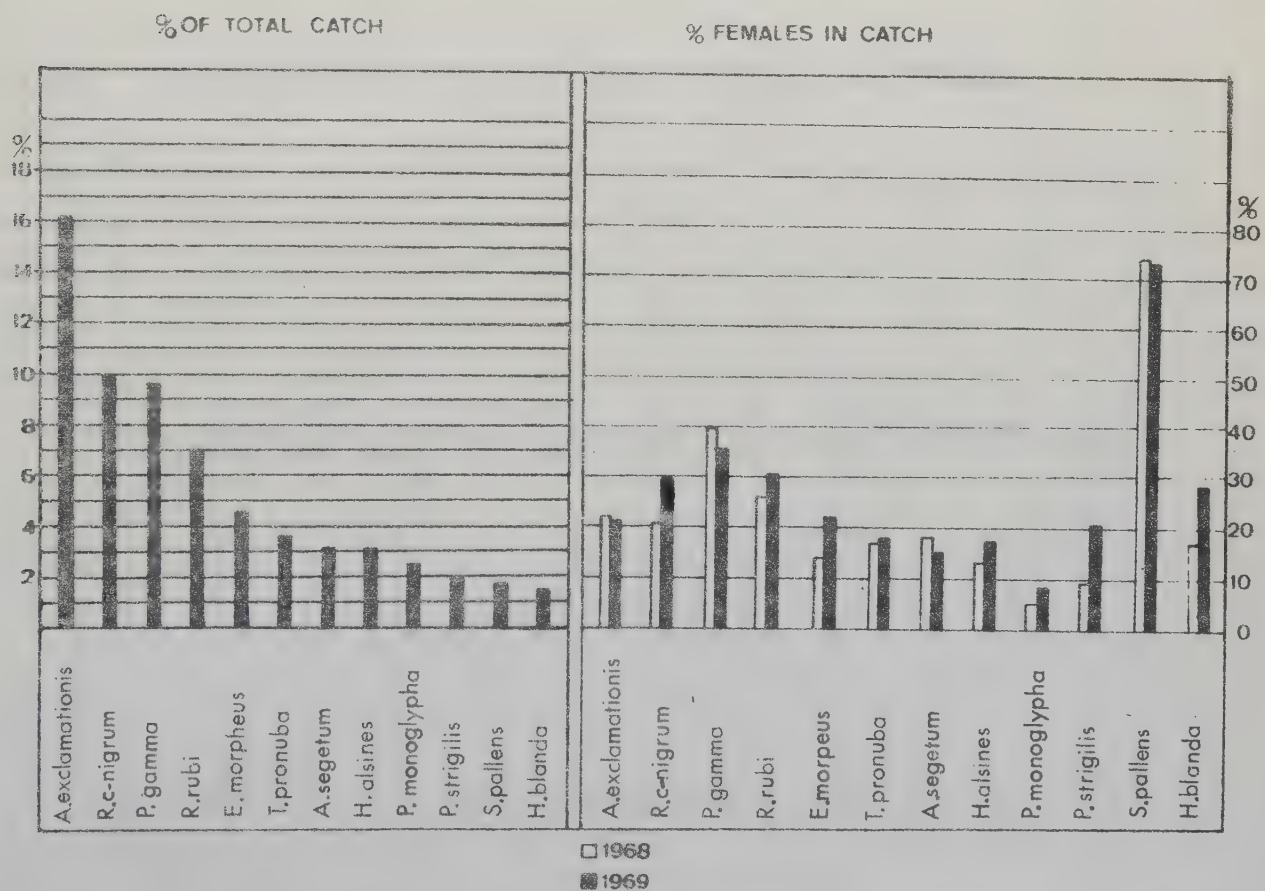






FIG.23

NOCTURNAL DISTRIBUTION OF CATCH

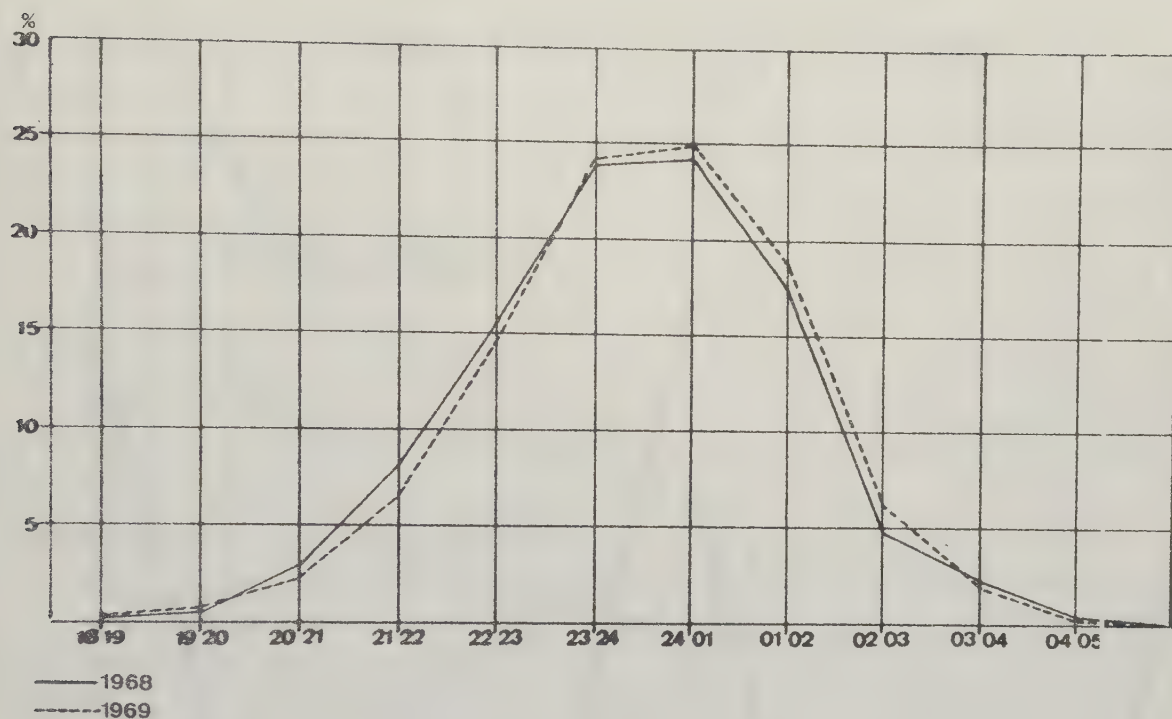


FIG.24 NOCTURNAL DISTRIBUTION OF CATCH OF MALES AND FEMALES

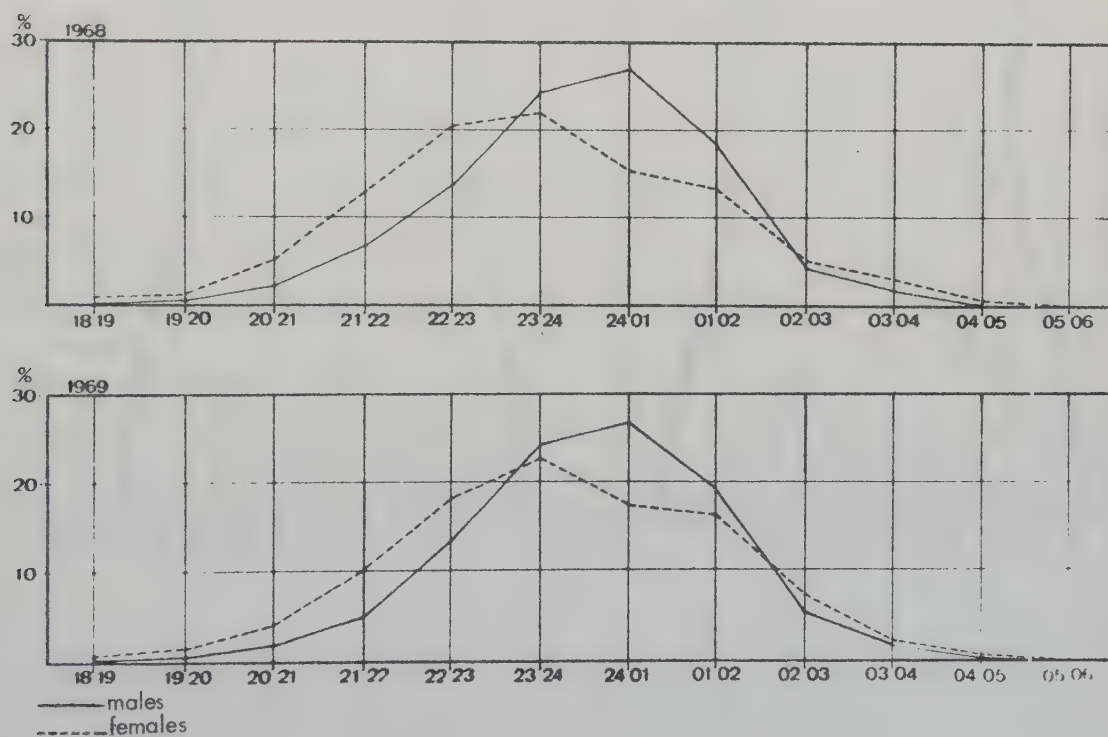
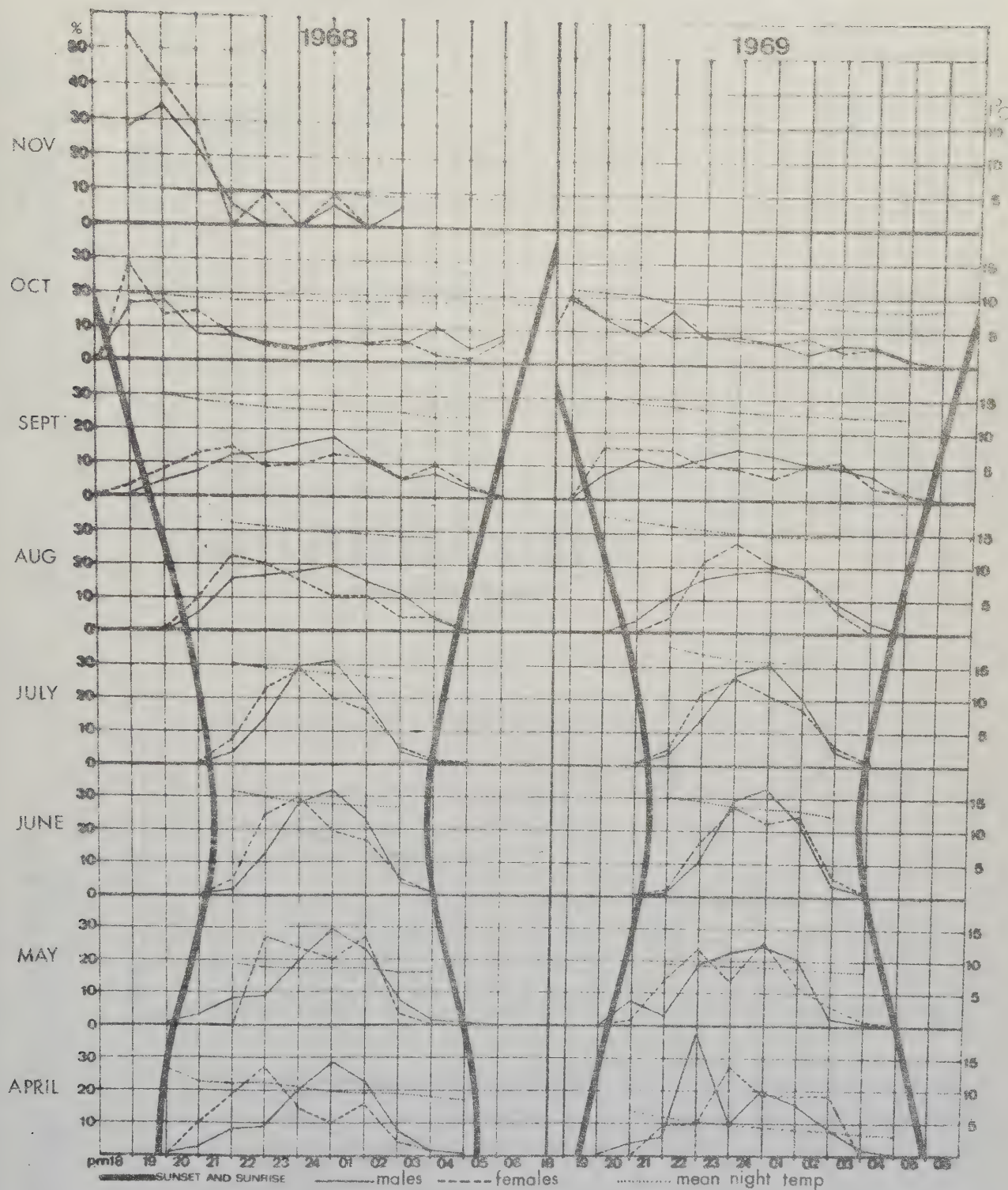




FIG.25 MONTHLY NOCTURNAL DISTRIBUTION OF CATCH

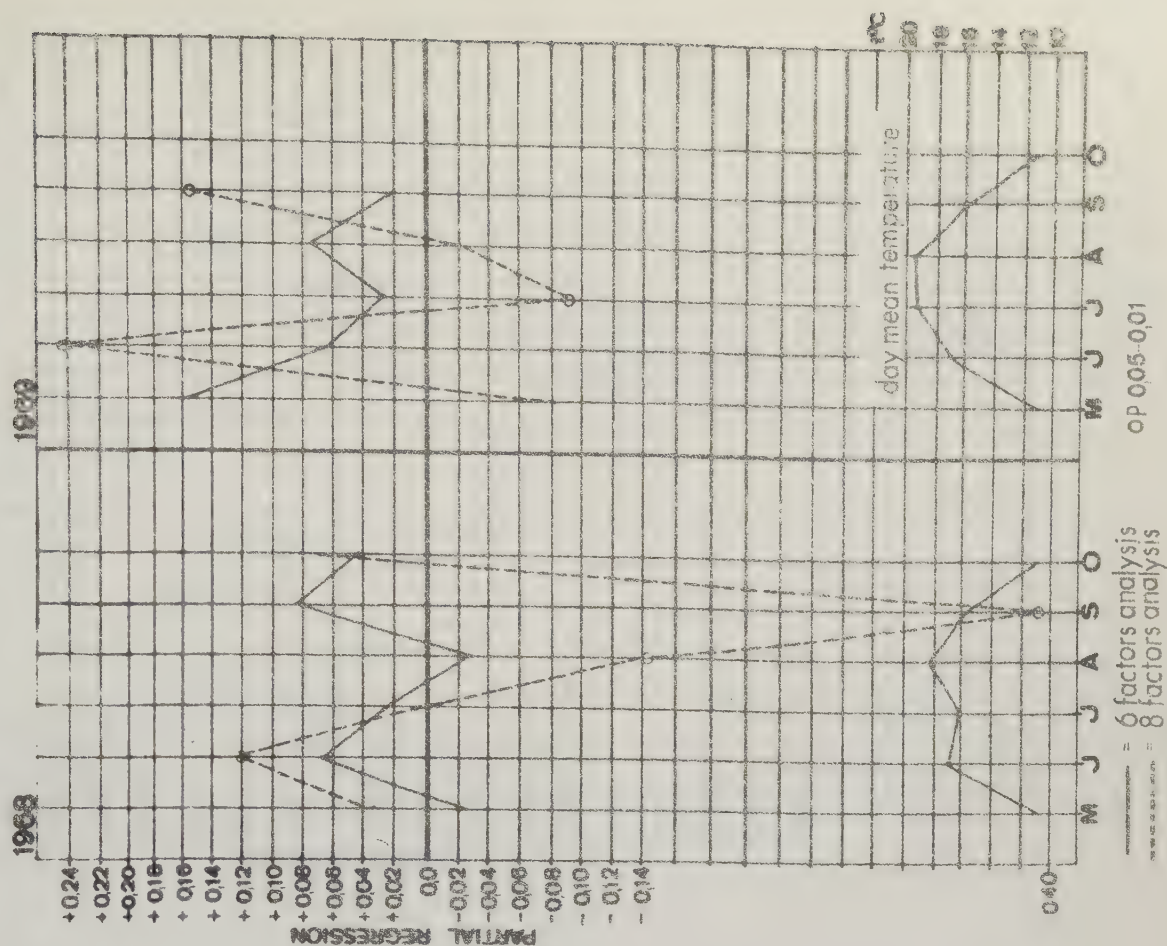






MONTHLY PARTIAL REGRESSION ON  
THE DAY MEAN TEMPERATURE

FIG.27



MONTHLY PARTIAL REGRESSION ON  
THE MEAN NIGHT TEMPERATURE

FIG.26

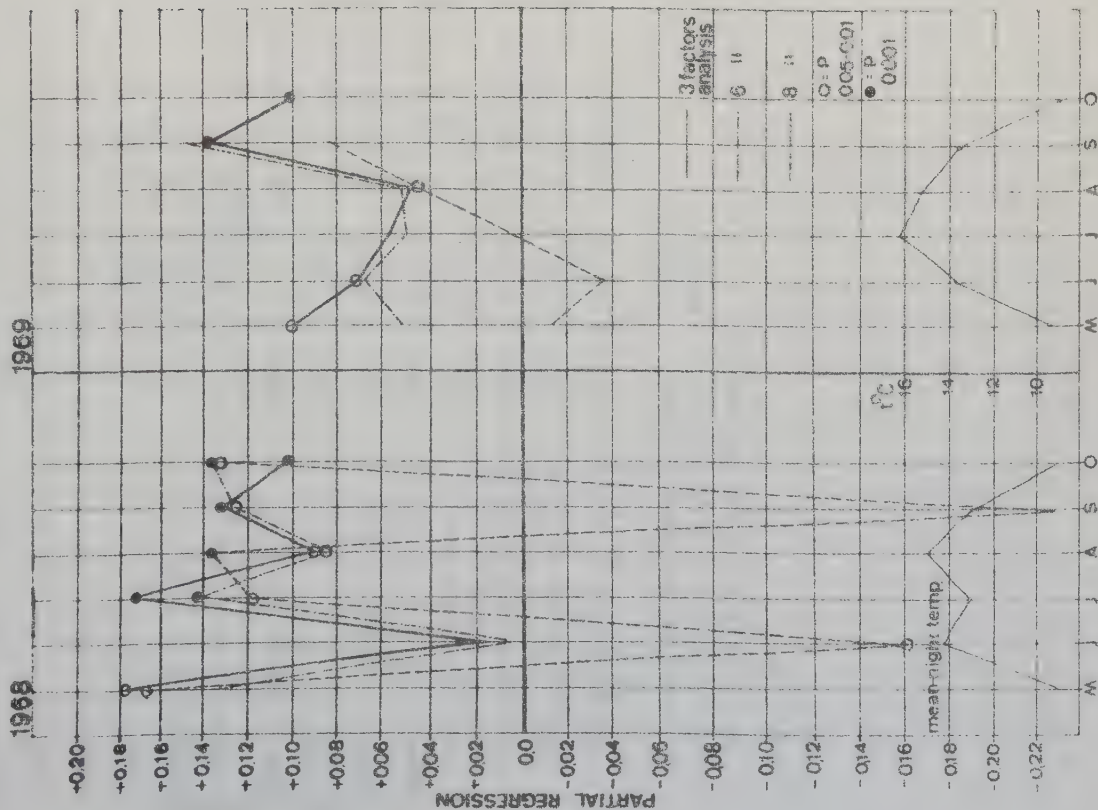




FIG.28 MONTHLY PARTIAL REGRESSION ON THE DAY MAXIMUM TEMPERATURE

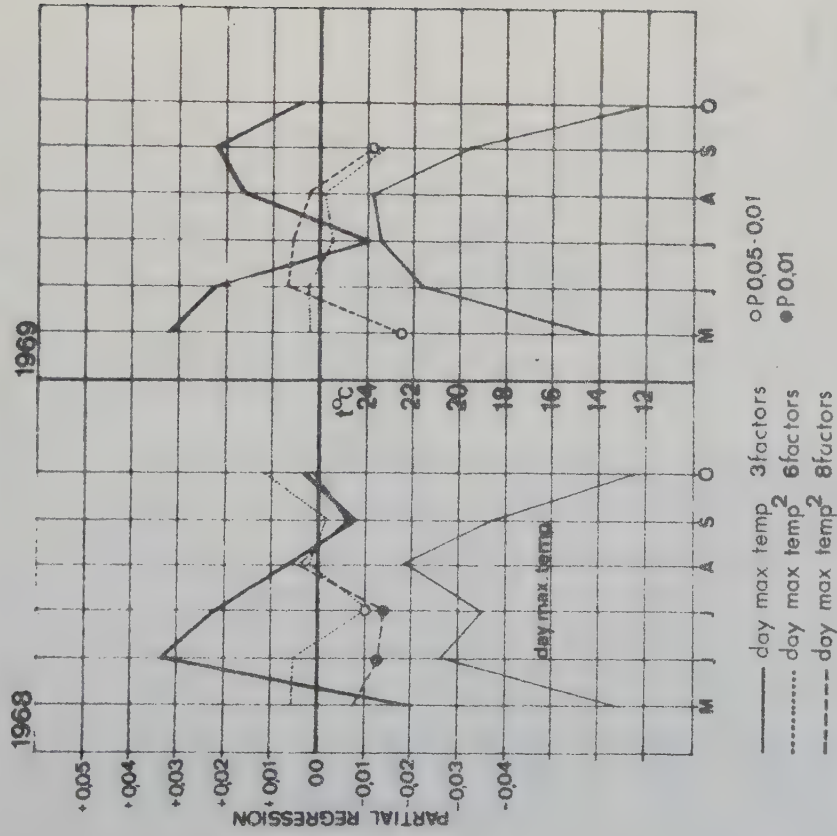


FIG.29 MONTHLY PARTIAL REGRESSION ON THE DAY MEAN VAPOR PRESSURE DEFICIT

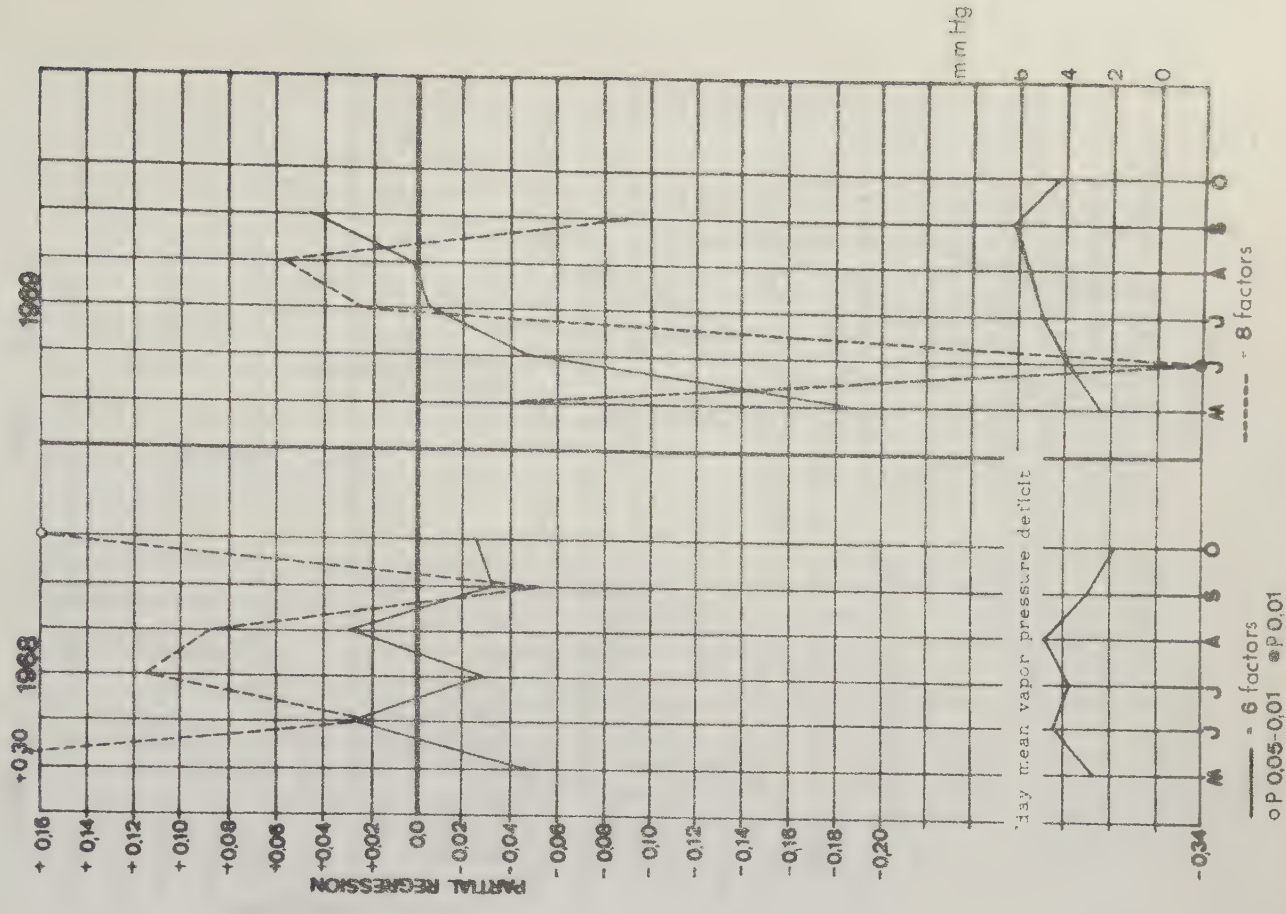






FIG.30 MONTHLY PARTIAL REGRESSION ON THE MEAN NIGHT WIND VELOCITY

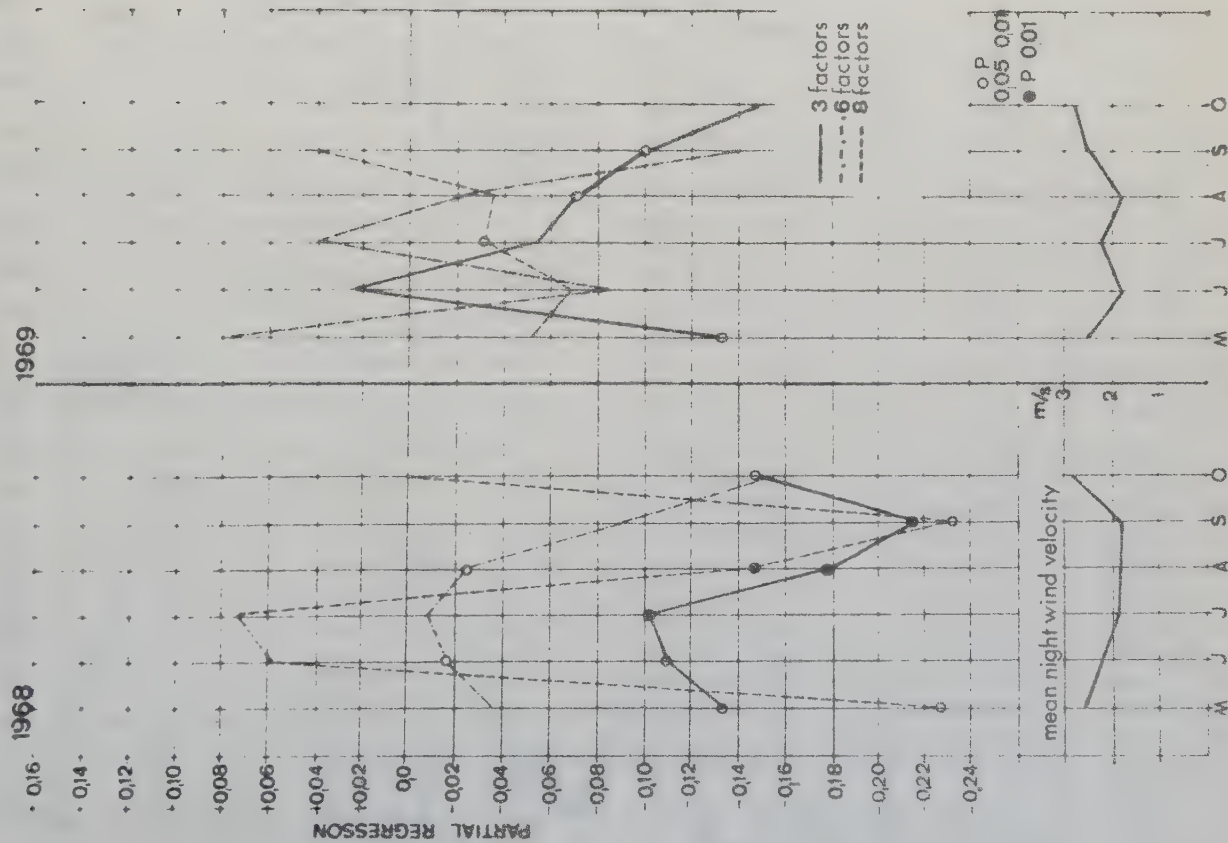


FIG.31 MONTHLY PARTIAL REGRESSION ON THE MEAN NIGHT WIND VELOCITY<sup>2</sup>

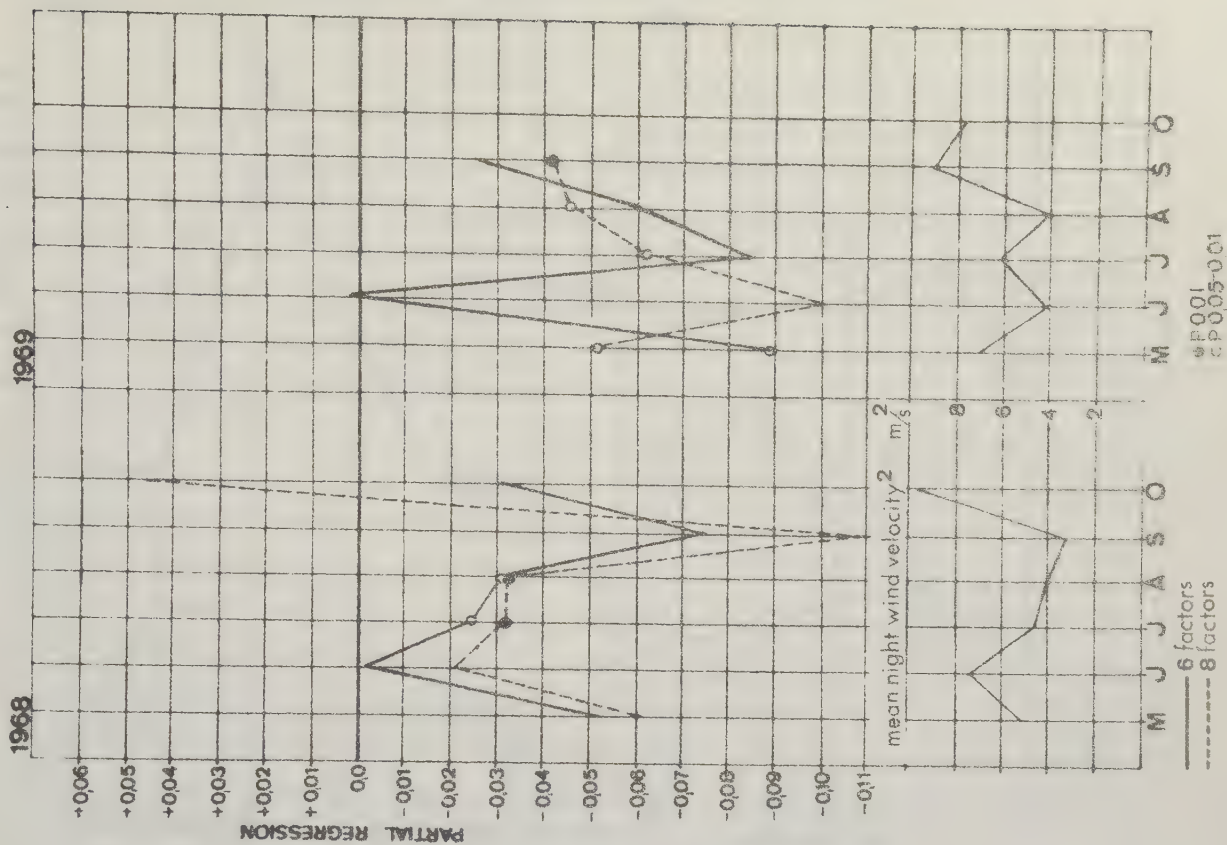




FIG.32

NO OF SIGN. PARTIAL REGRESSIONS AND SIMPLE CORRELATIONS

1968

1969

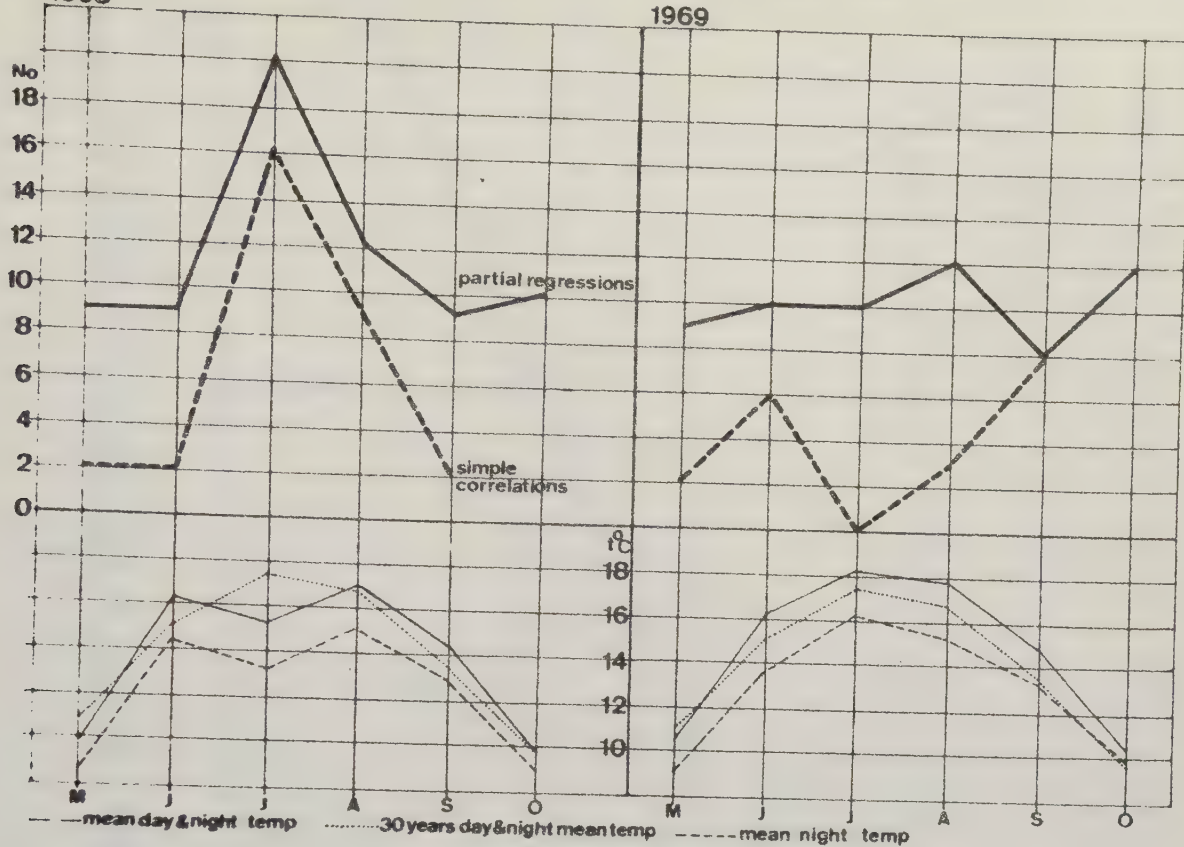


FIG.33

EXPLAINED VARIANCE

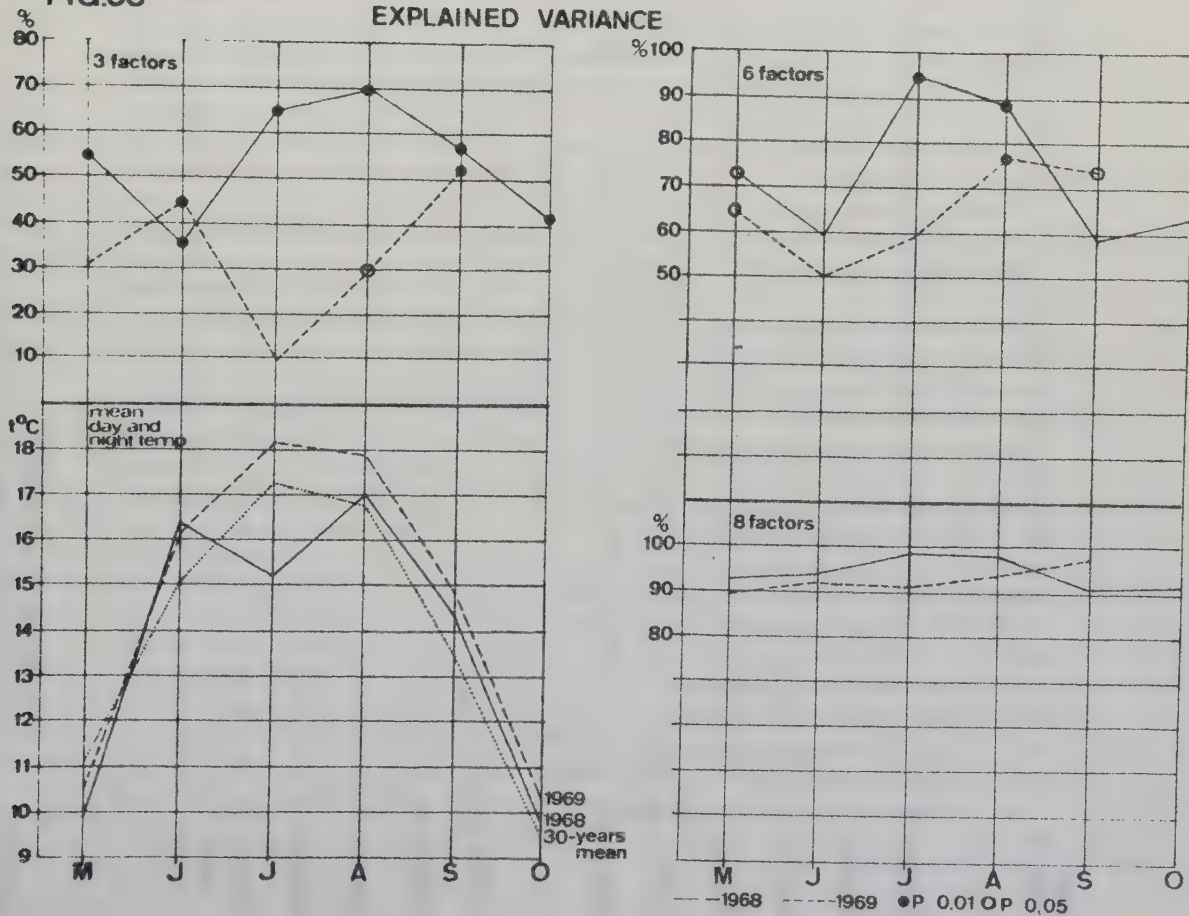






FIG. 34 DEPARTURE FROM CORRECTED LOG.CATCH WHEN RAIN OCCURRED

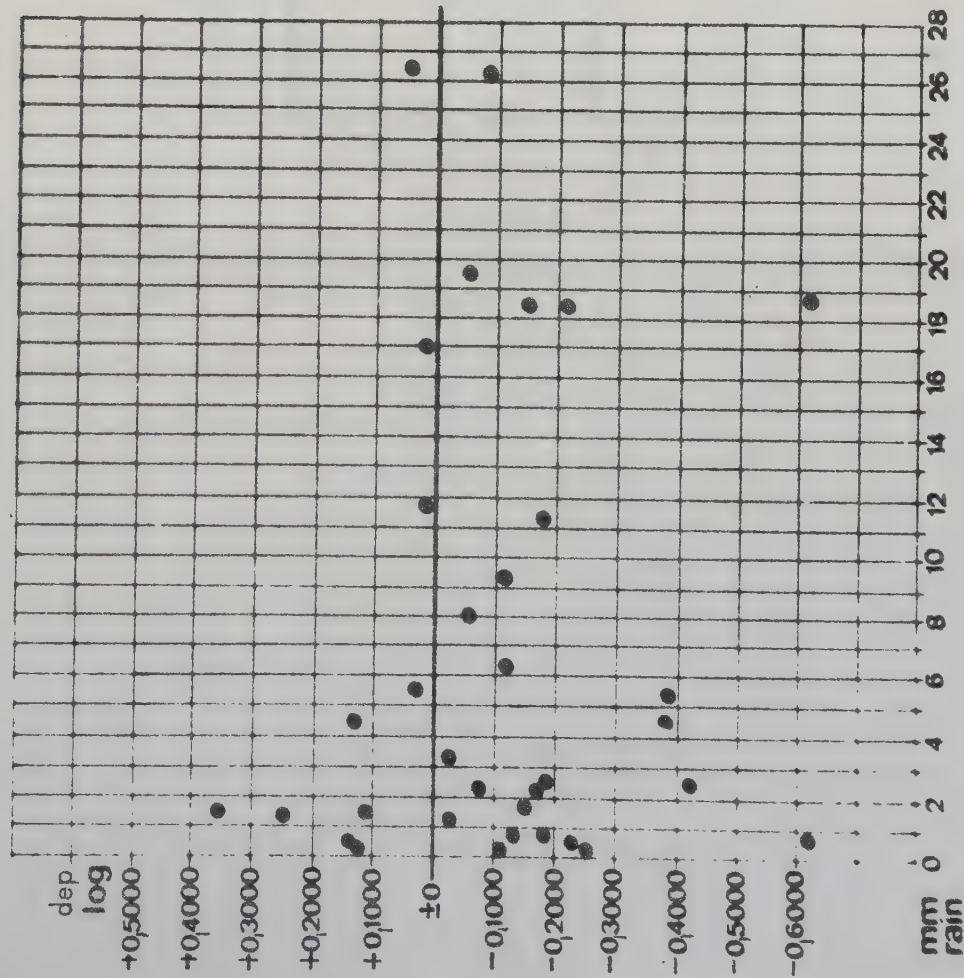


FIG. 35 DEPARTURE FROM CORRECTED LOG.CATCH WHEN RAIN OCCURED, IN RELATION TO THE TEMPERATURE

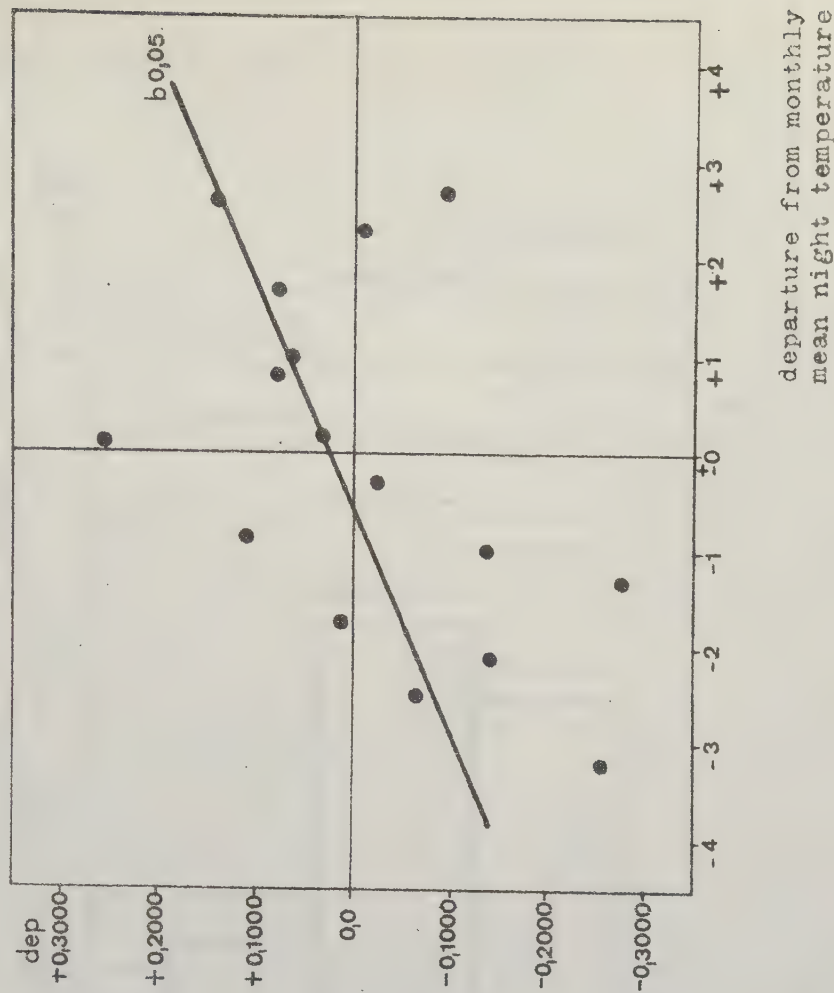




Fig.36 MEAN CATCH PER AIR PRESSURE GROUP

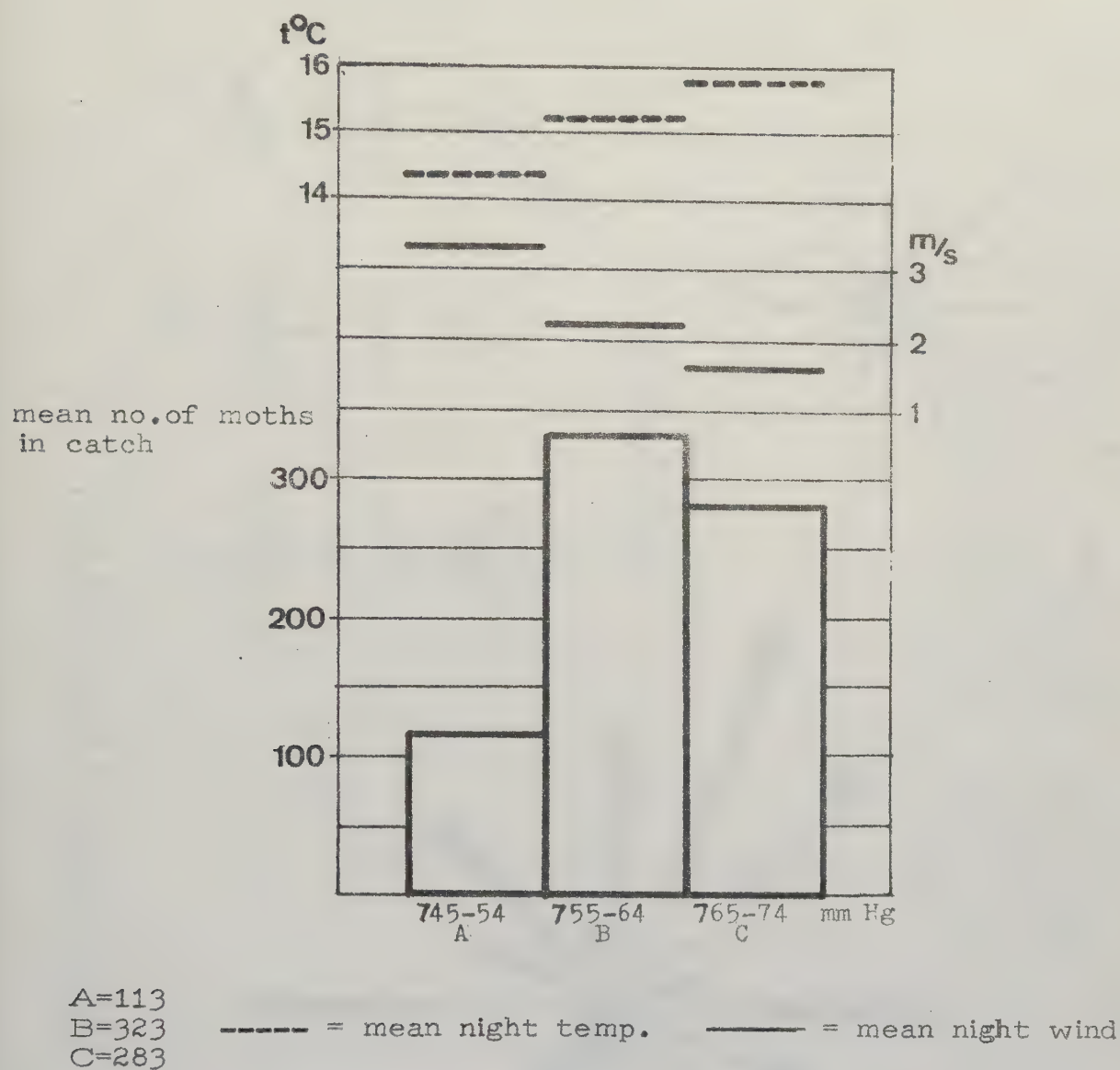






FIG.37 WIND DIRECTION AND CATCH 1968

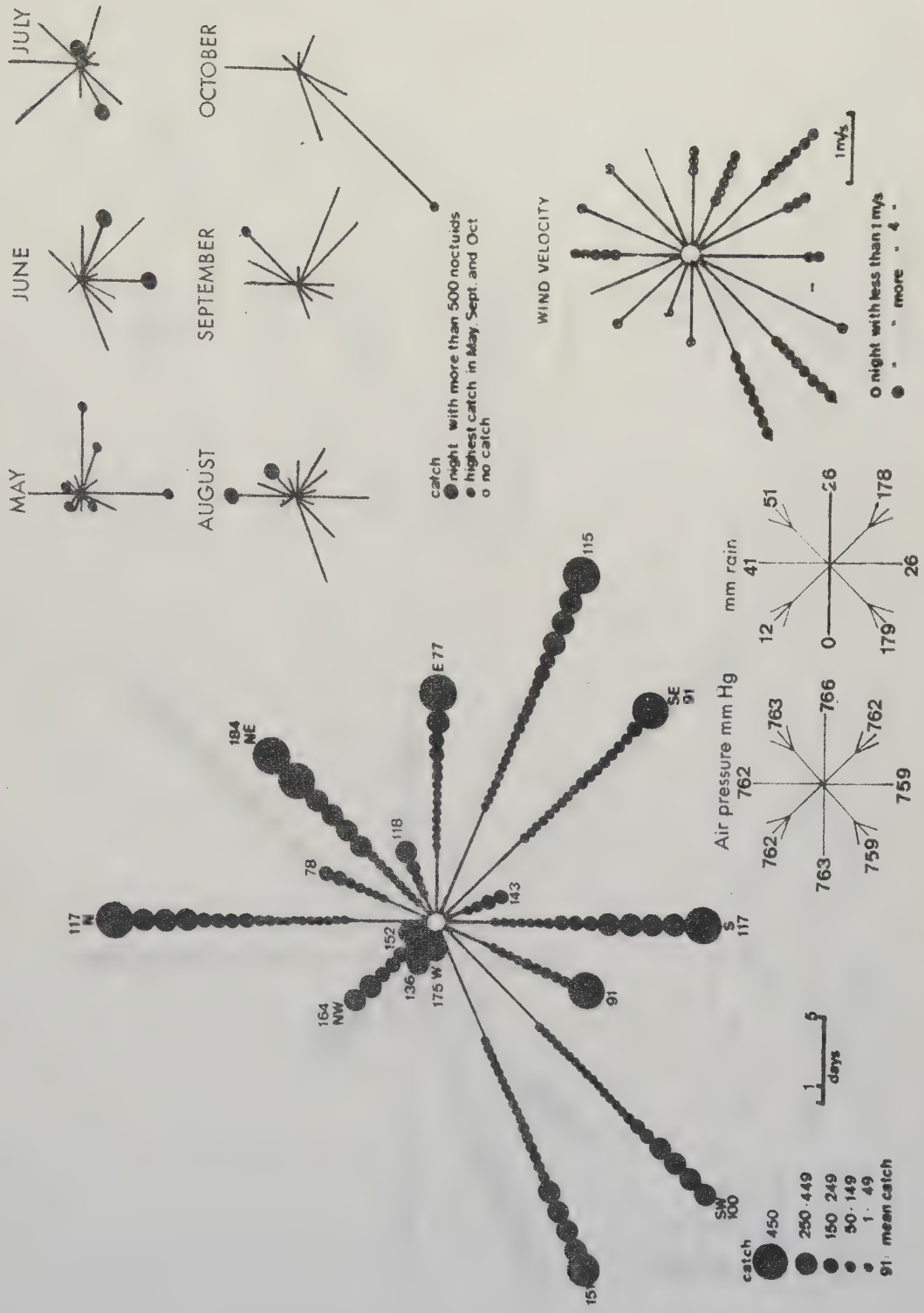




FIG.38 WIND DIRECTION AND CATCH 1969

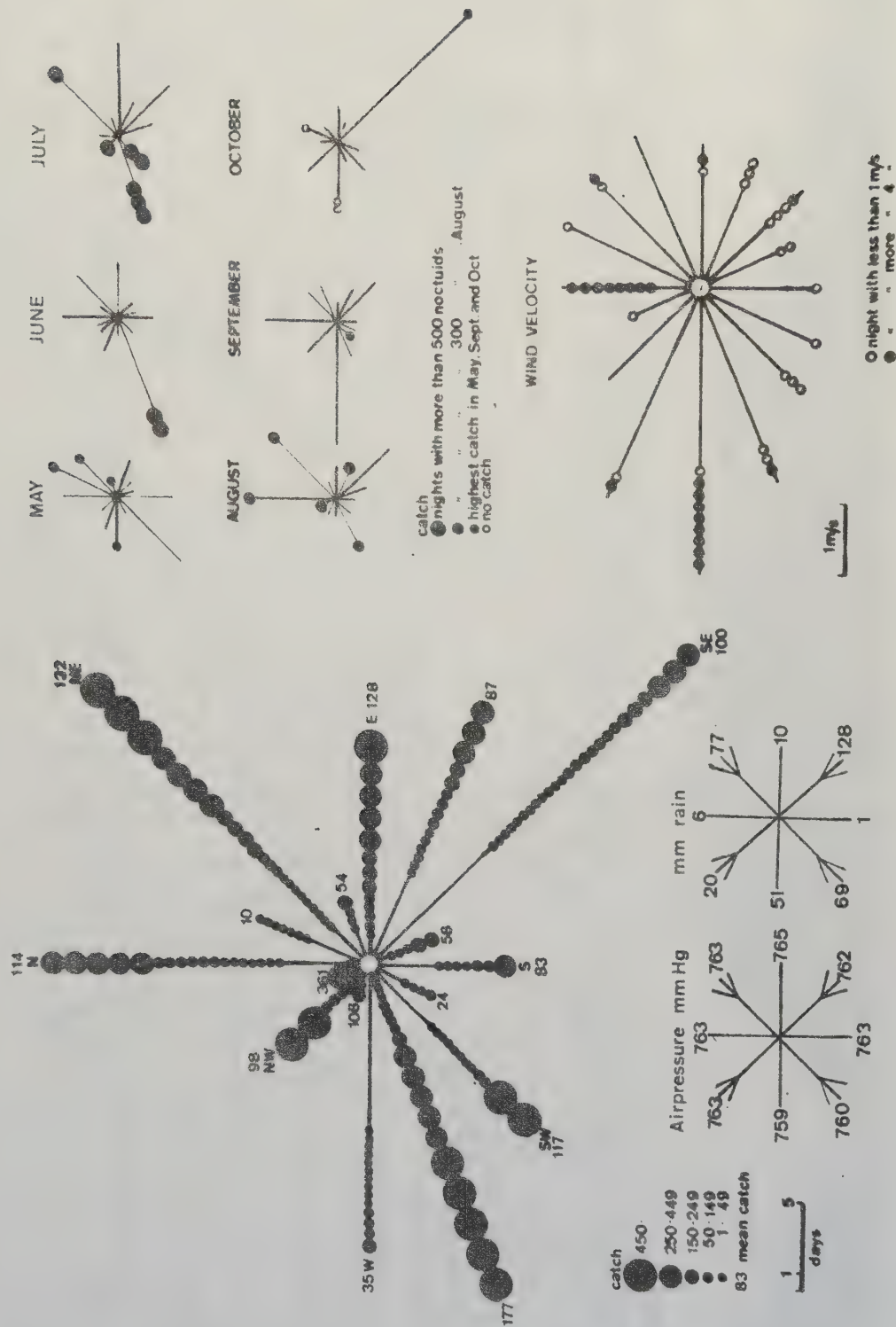






FIG.39 DAILY CATCH 1968 IN RELATION TO WEATHER FACTORS

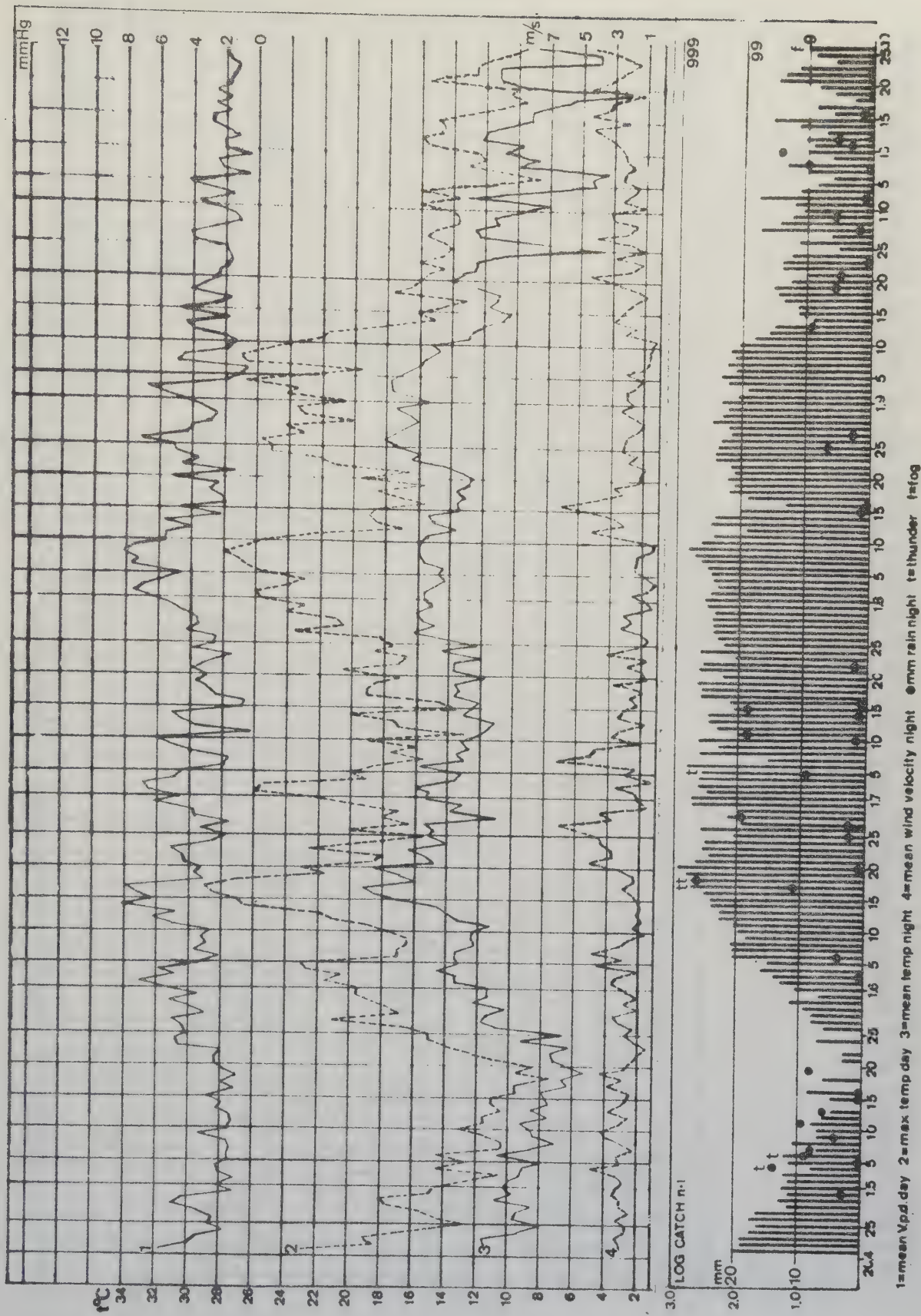
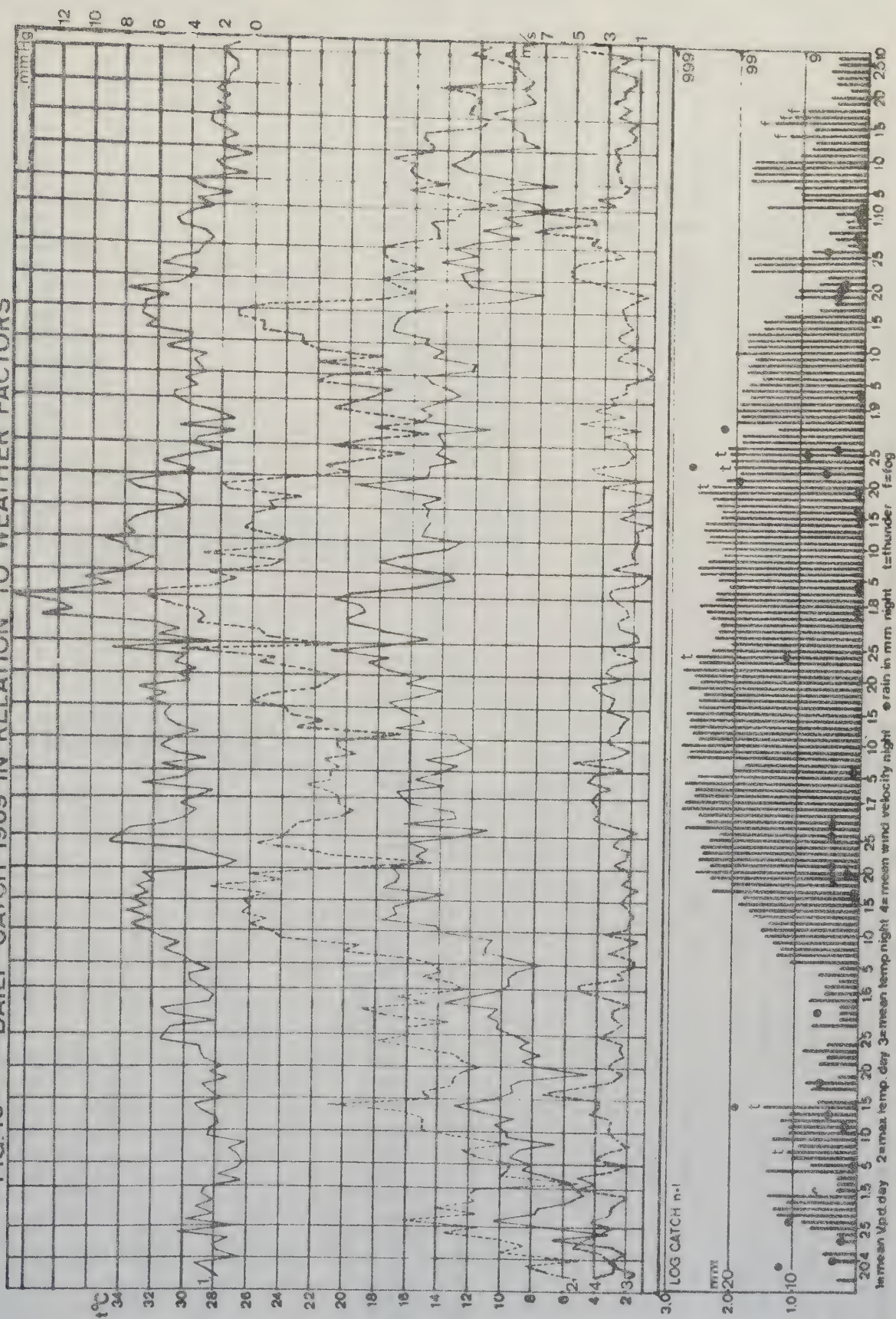




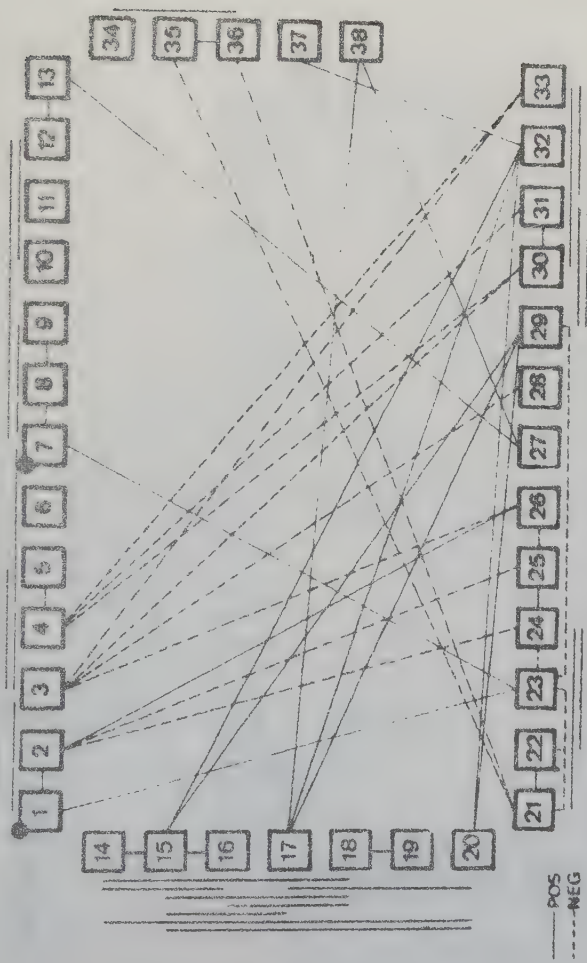


FIG.40 DAILY CATCH 1969 IN RELATION TO WEATHER FACTORS

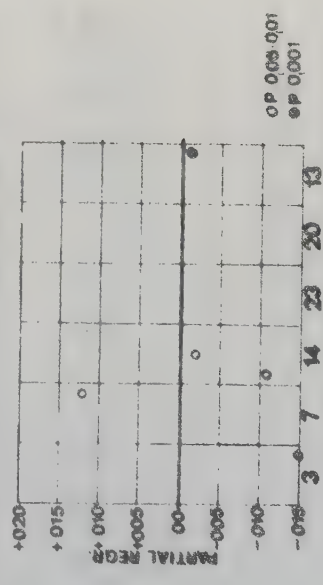






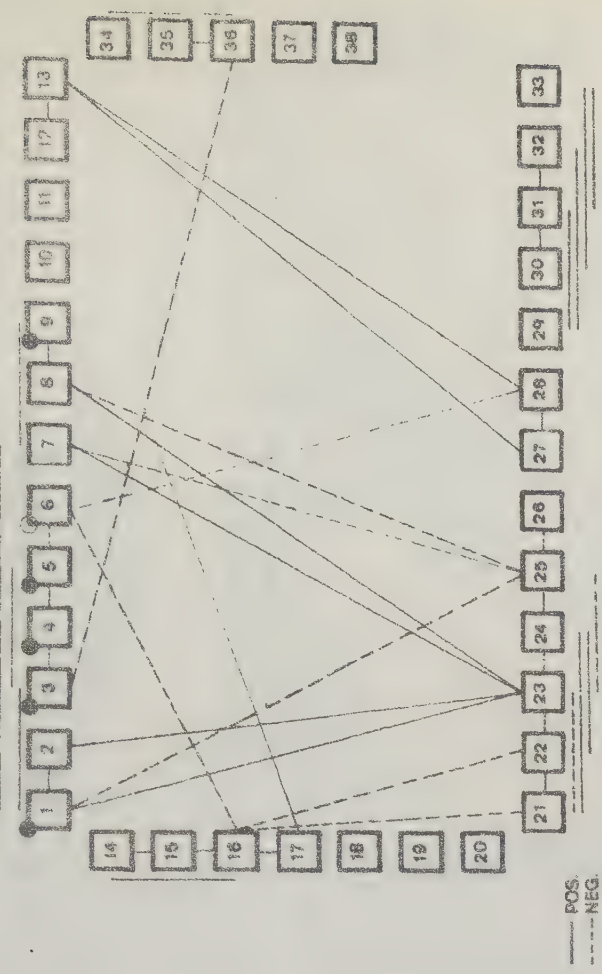


● SIGMA POS  
○ CORRELATED TO CATCH

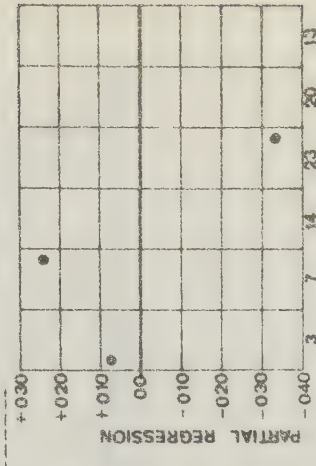


Weather factors:

- 1.mean day and night temp.
- 2.day and night temp.range
- 3.mean night temp.
- 4.maximum night temp.
- 5.minimum night temp.
- 6.night temperature range
- 7.mean day temp.
- 8.maximum day temp.
- 9.day temperature range
- 10.mean night temperature
- 11.night temperature range<sup>2</sup>
- 12.mean day temperature<sup>2</sup>
- 13.maximum day temperature<sup>2</sup>
- 14.mean night wind velocity
- 15.maximum night wind velocity
- 16.minimum night wind velocity
- 17.night wind velocity range
- 18.mean day wind velocity
- 19.maximum day wind velocity
- 20.mean night wind velocity<sup>2</sup>
- 21.mean night relative humidity



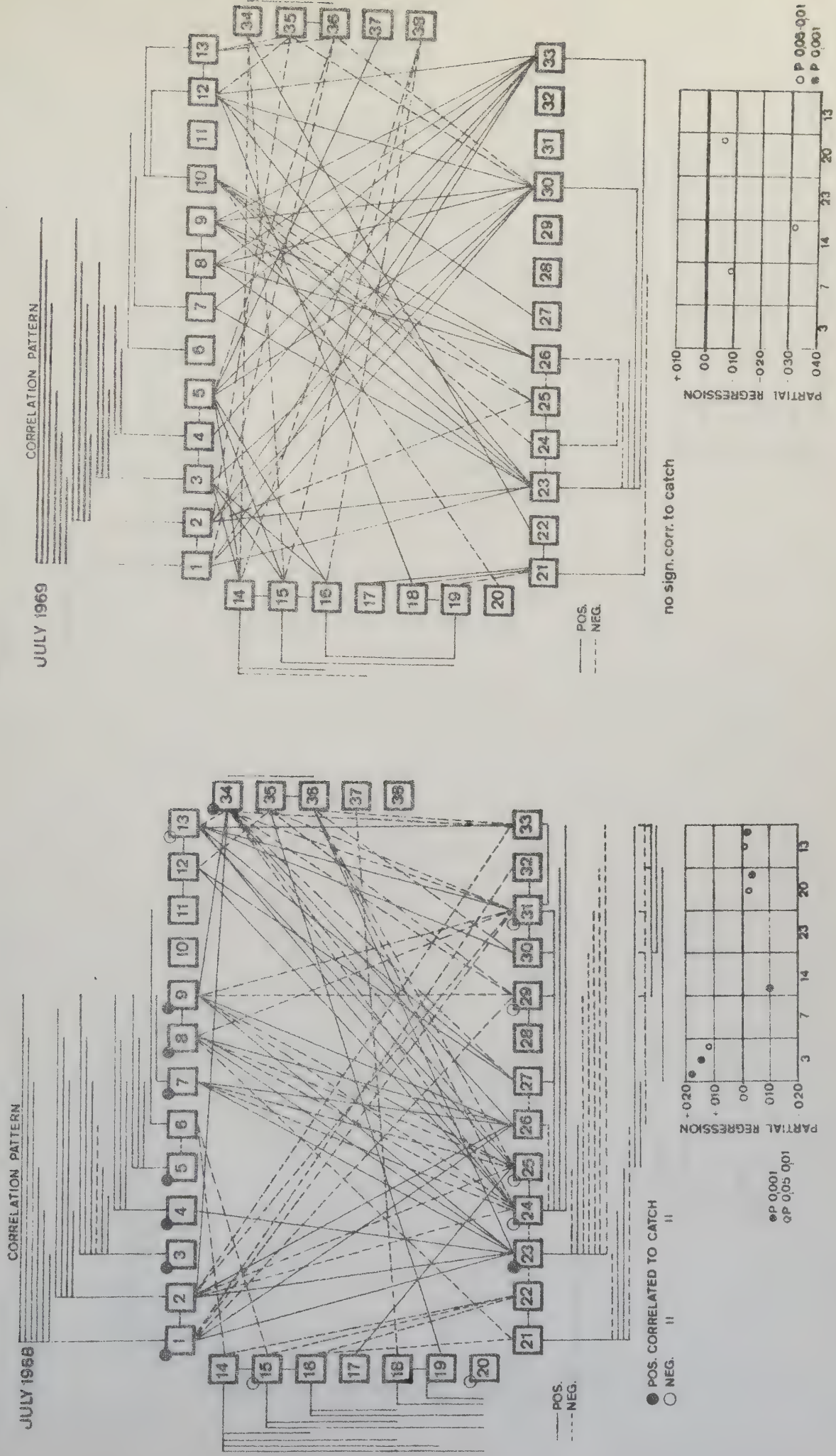
● POS CORRELATED TO CATCH  
○ NEG CORRELATED TO CATCH



- 22.maximum night relative humidity
- 23.mean day vapor pressure deficit
- 24.mean day relative humidity
- 25.minimum day relative humidity
- 26.day relative humidity range
- 27.mean day vapor pressure deficit<sup>2</sup>
- 28.mean night relative humidity<sup>2</sup>
- 29.mm rainfall day
- 30.mm rainfall night
- 31.mm rainfall day and night
- 32.rainfall day<sup>2</sup>
- 33.rainfall night<sup>2</sup>
- 34.mean day and night air pressure
- 35.air pressure trend
- 36.mean day and night air pressure<sup>2</sup>
- 37.air pressure trend<sup>2</sup>
- 38.mean night temp.x mean night wind



FIG.43



See fig.41 for explanation







FIG.45

AUGUST 1968

CORRELATION PATTERN

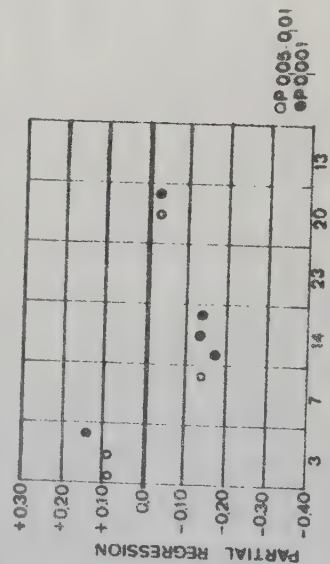
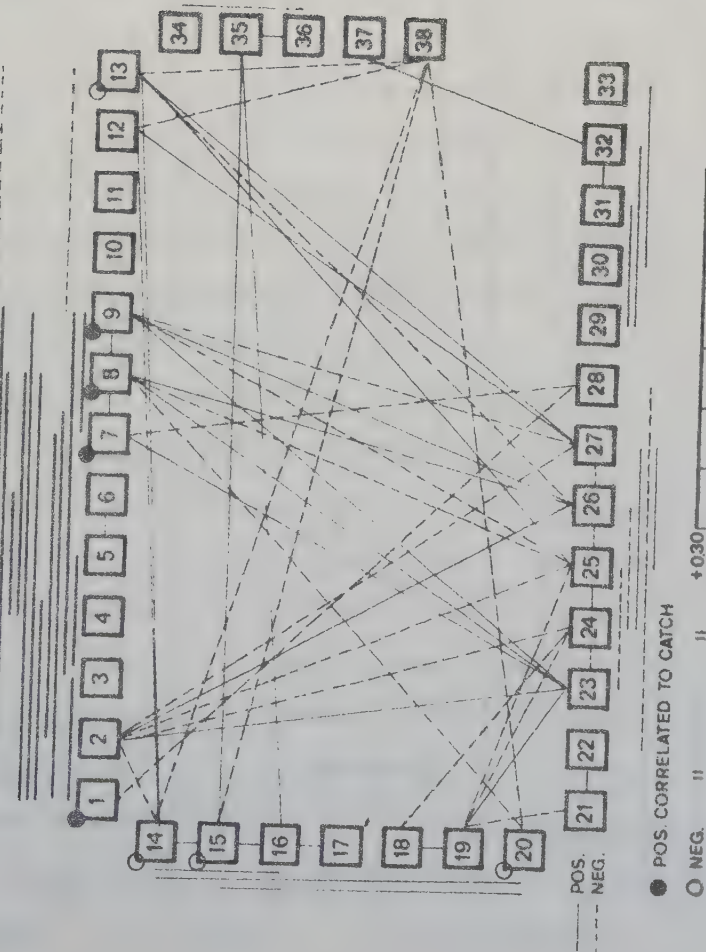
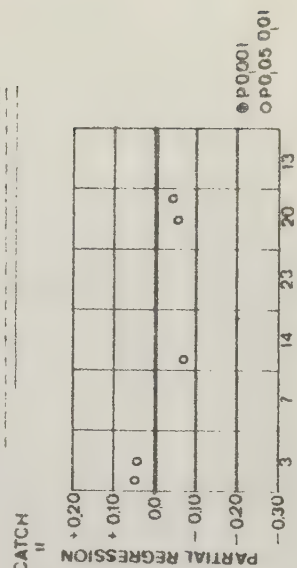
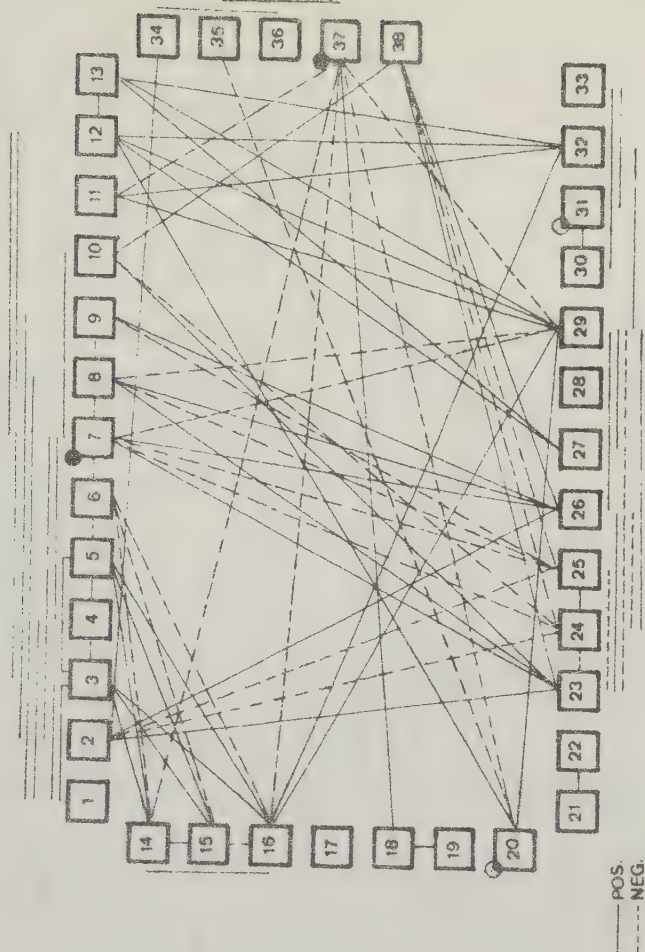


FIG.46

AUGUST 1969

CORRELATION PATTERN



See fig.41 for explanation



FIG.47

CORRELATION BETWEEN CATCH PER HOUR AND TEMPERATURE

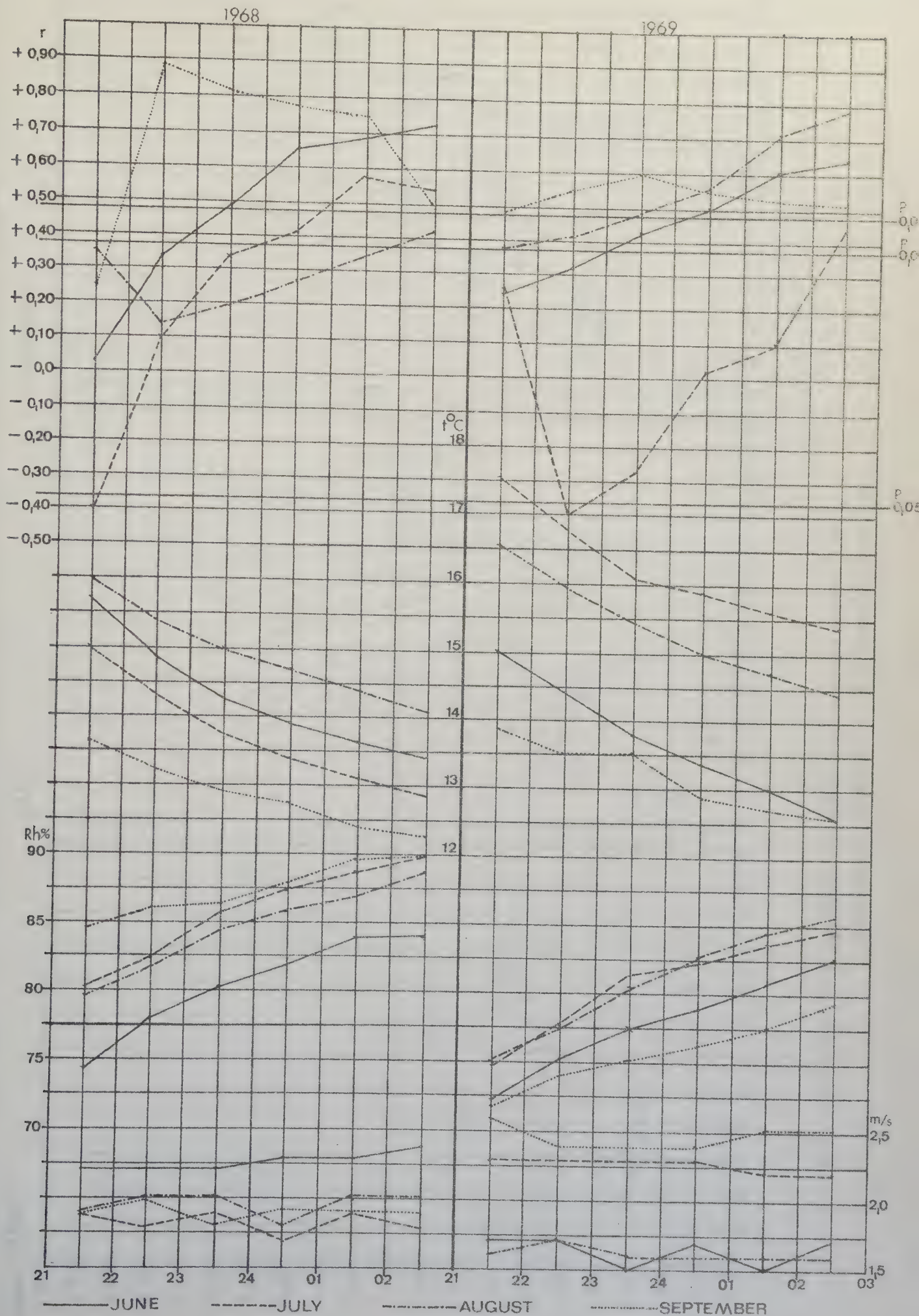








FIG.48

CHANGE IN CATCH FROM 2300-2400 TO 0100-0200 IN RELATION TO TEMPERATURE CHANGES

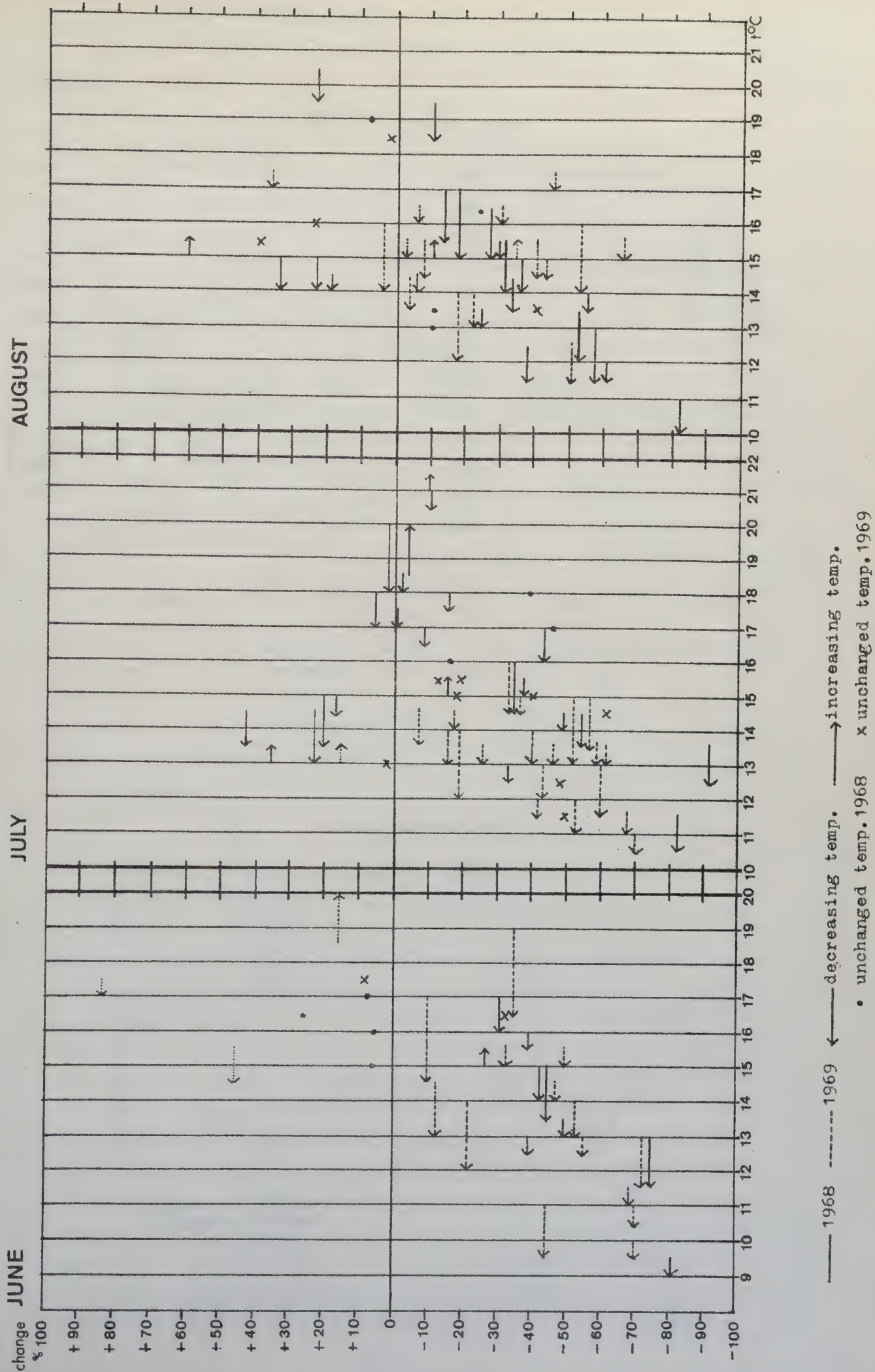




FIG.49

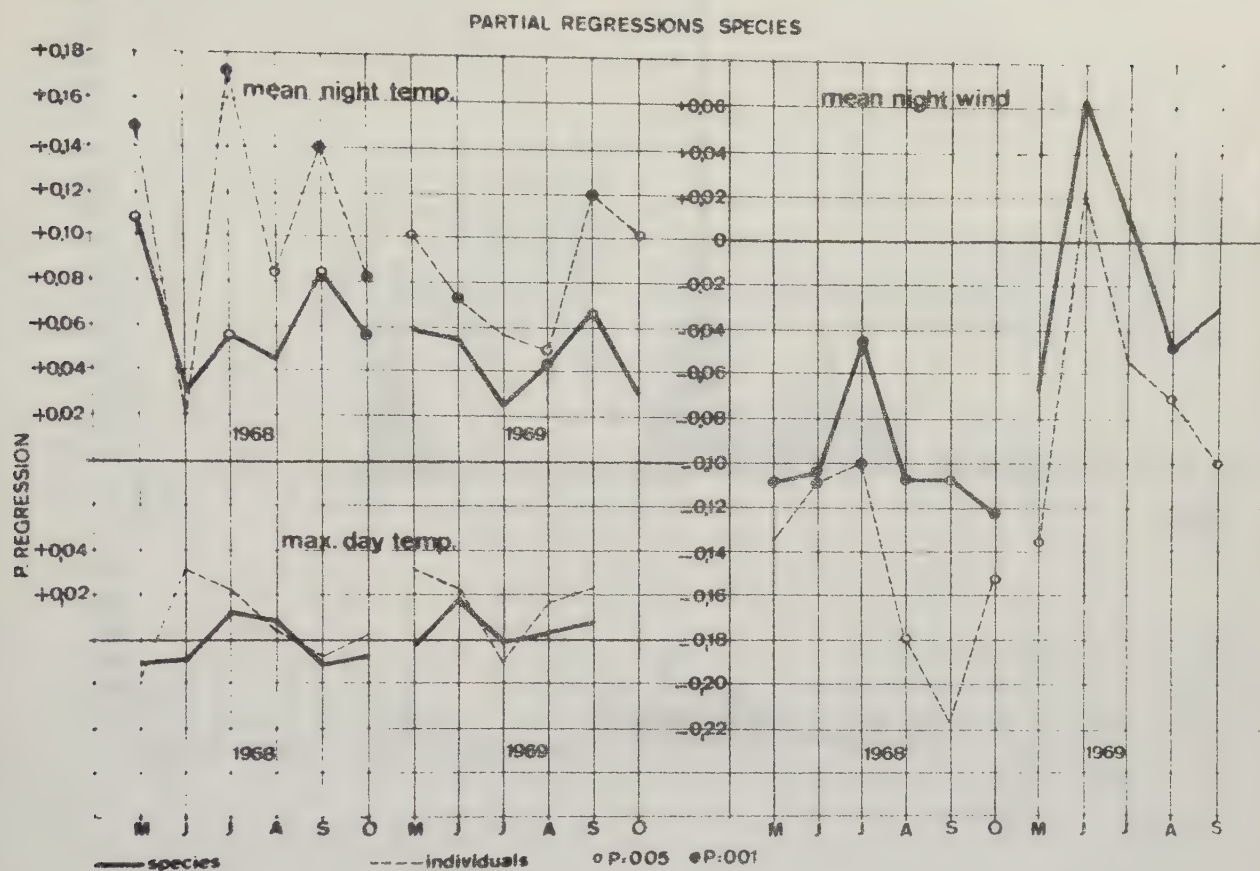


FIG.50

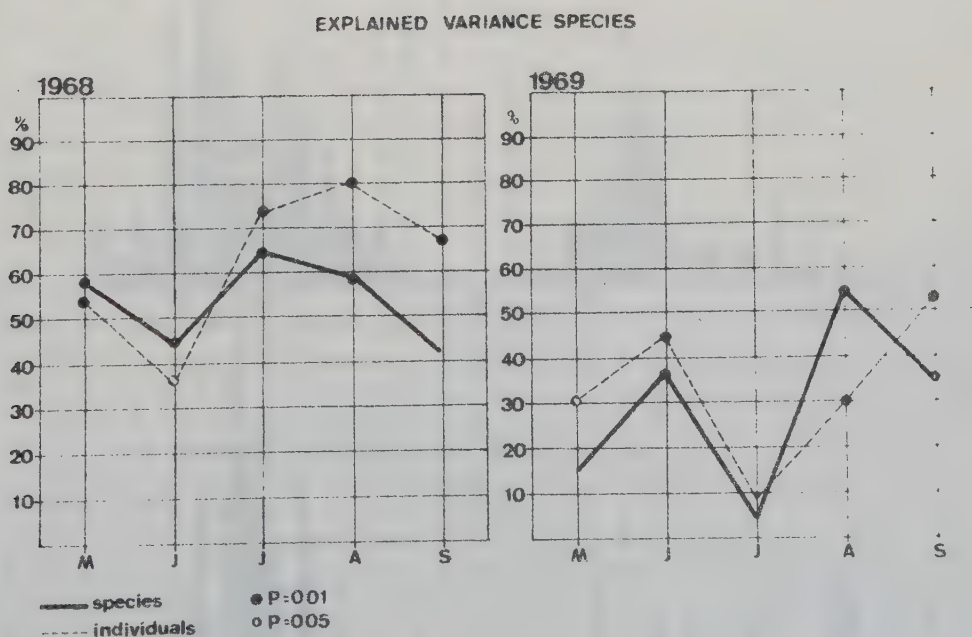






FIG.51

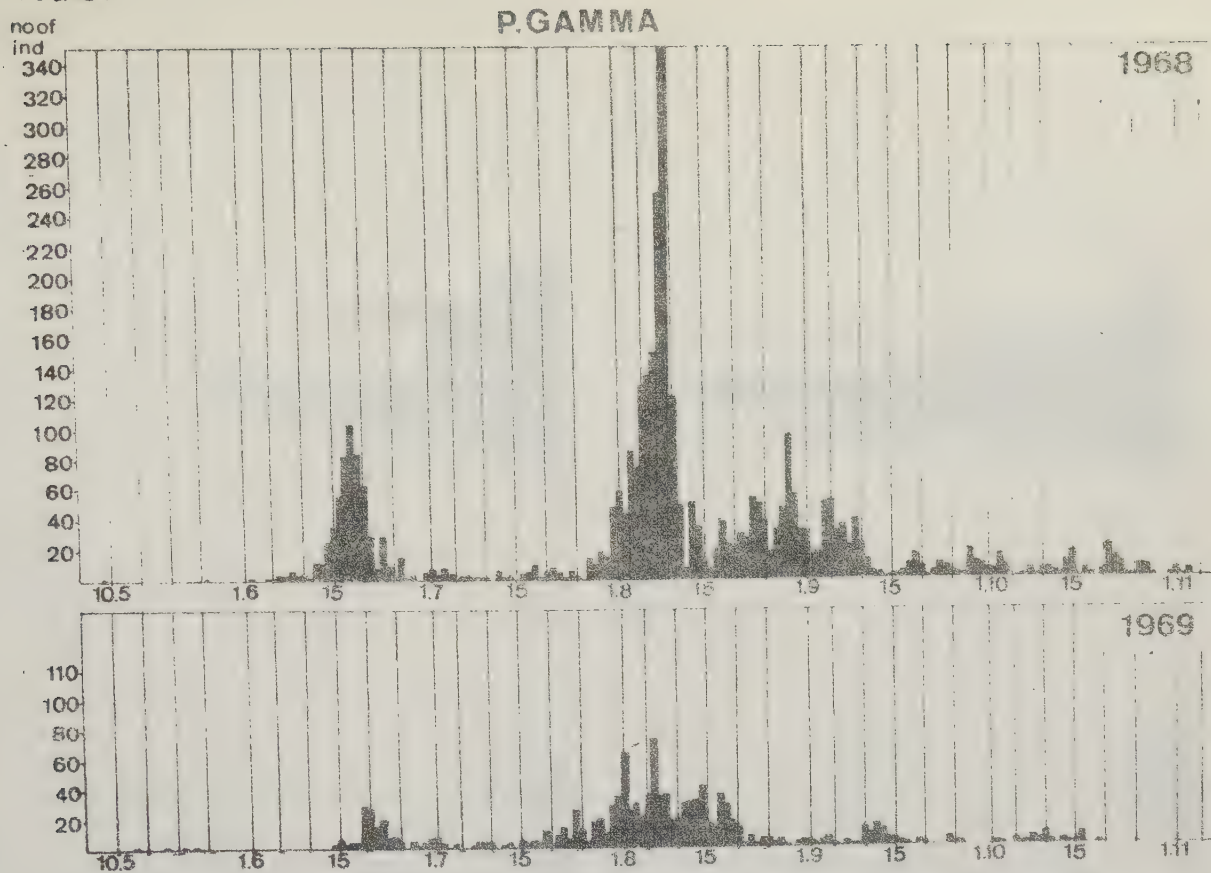


FIG.52

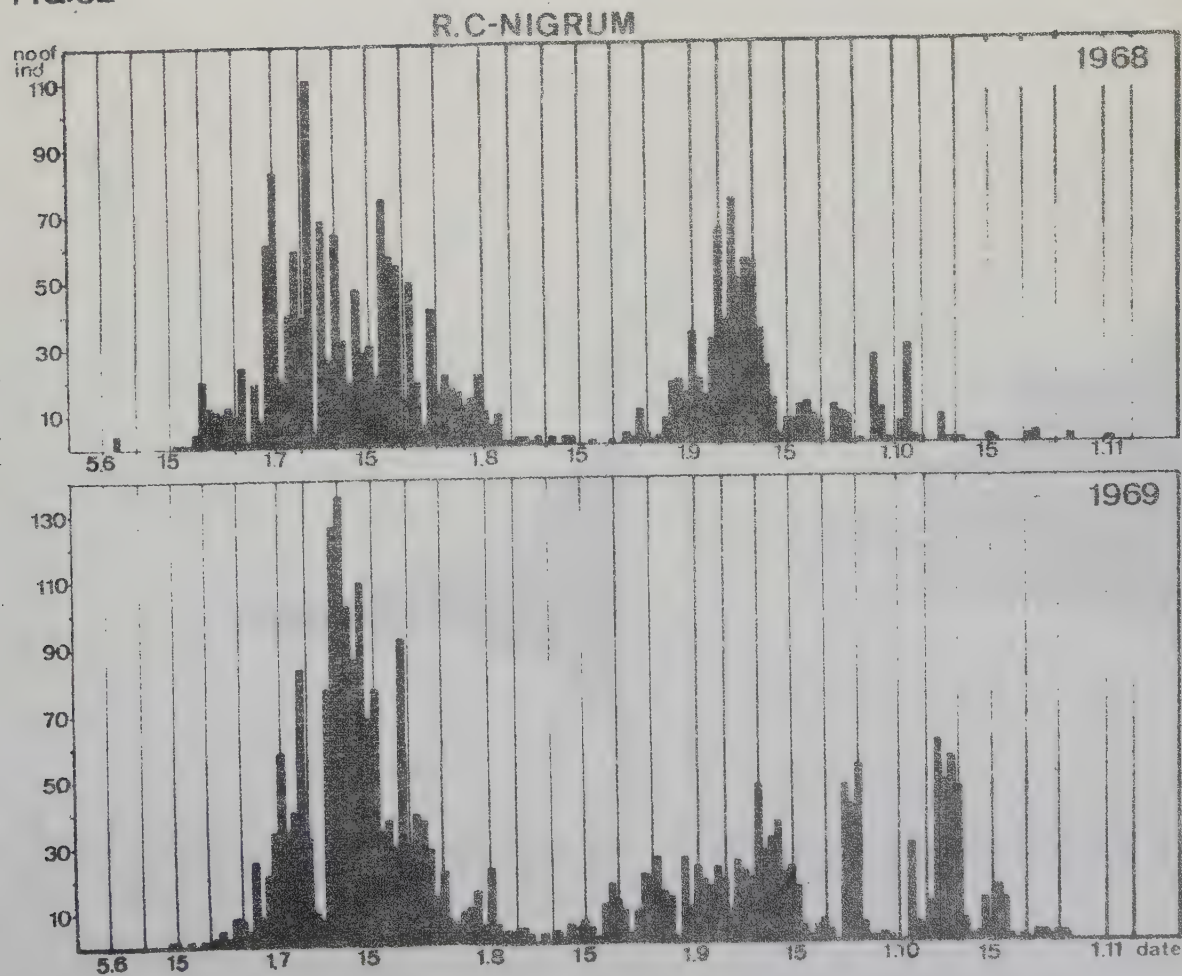




FIG.53 A.EXCLAMATIONIS

FIG.54 R.RUBI

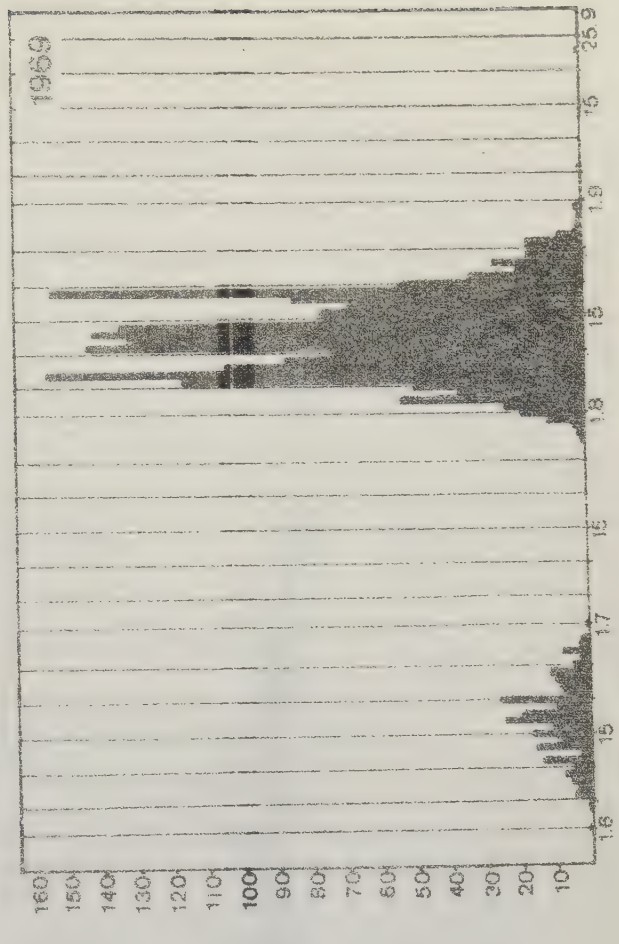
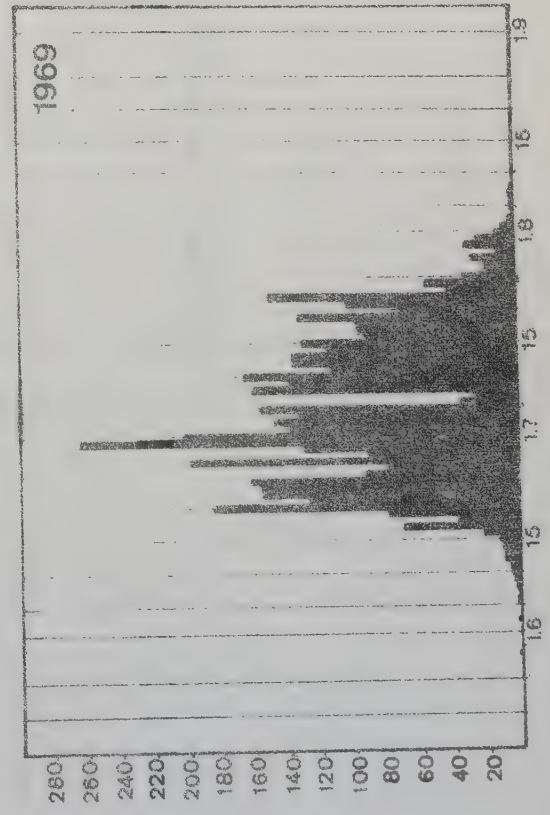
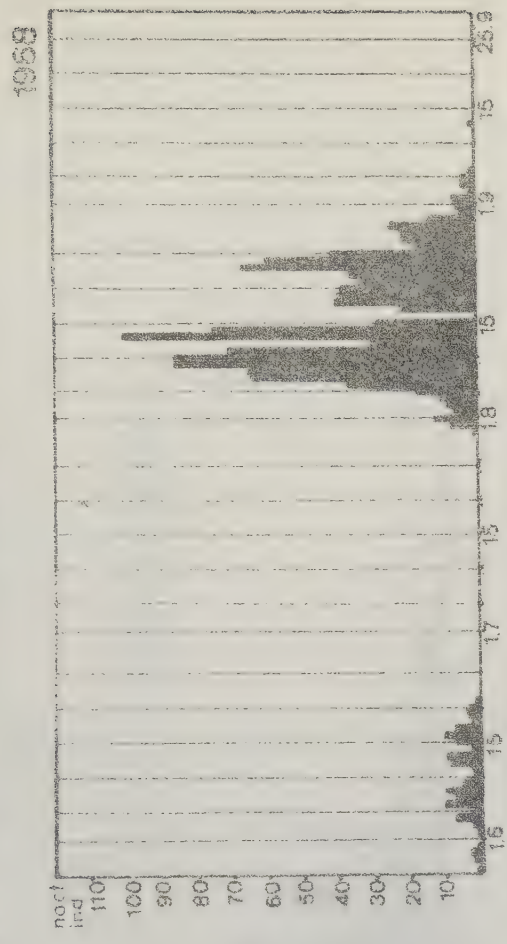
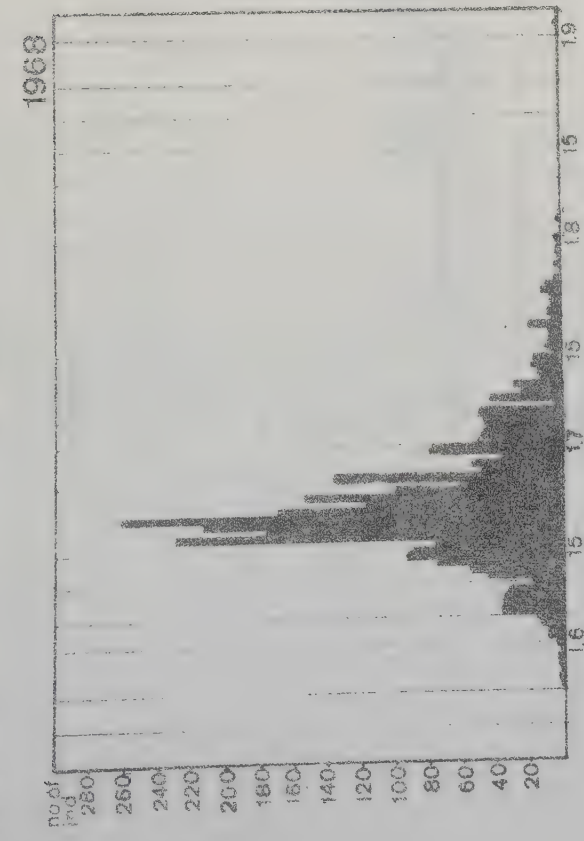






FIG.55

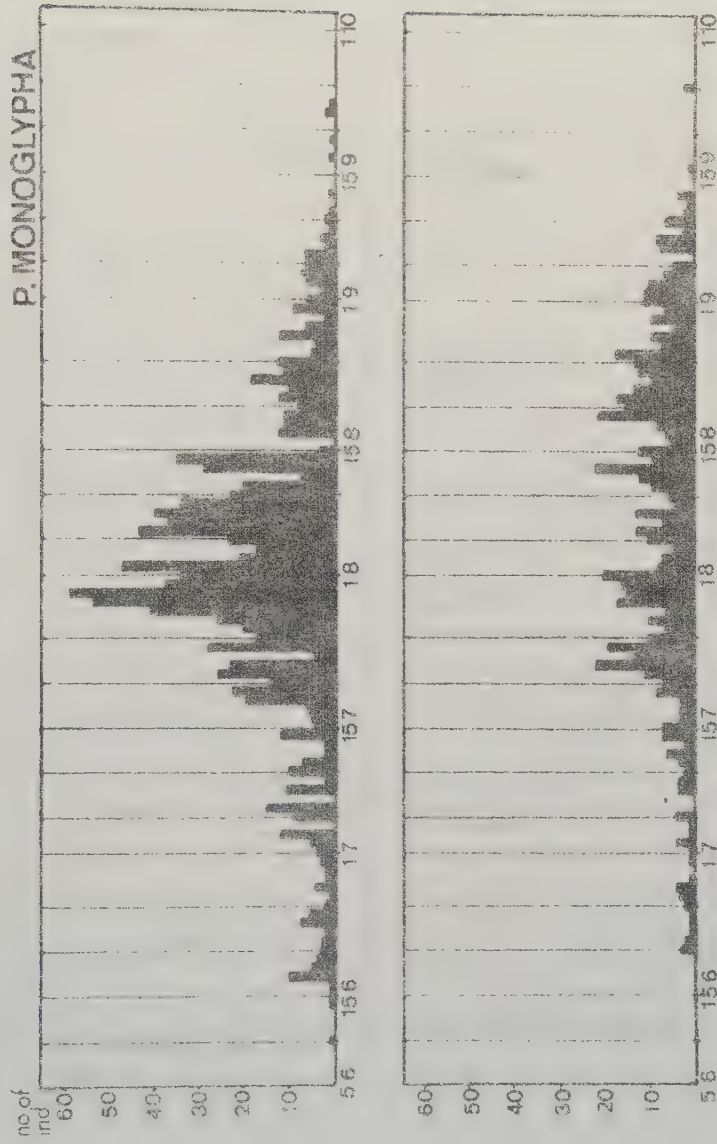




FIG.56

# NOCTURNAL DISTRIBUTION OF CATCH

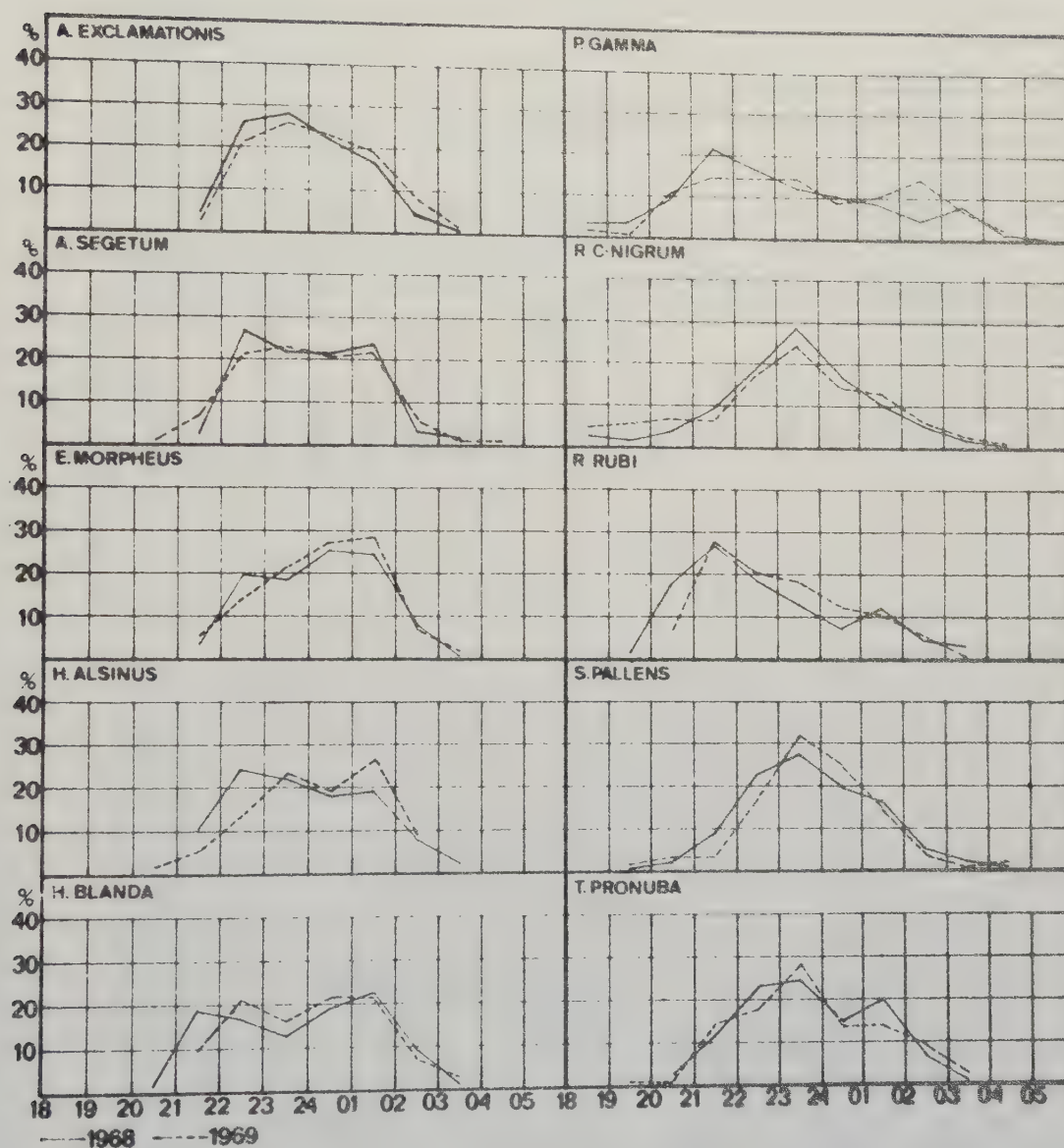






FIG.58

FLIGHT IN DIFFERENT WIND VELOCITIES

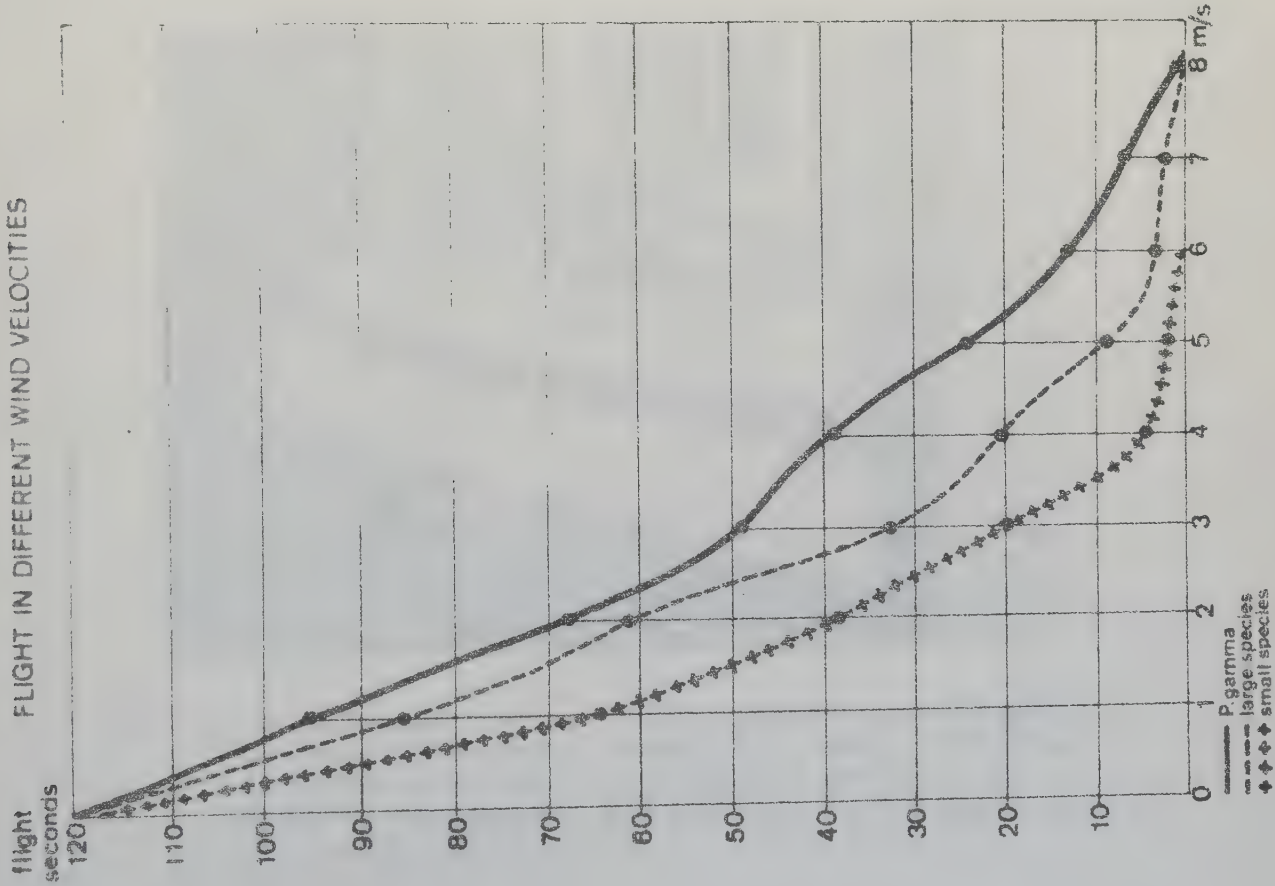
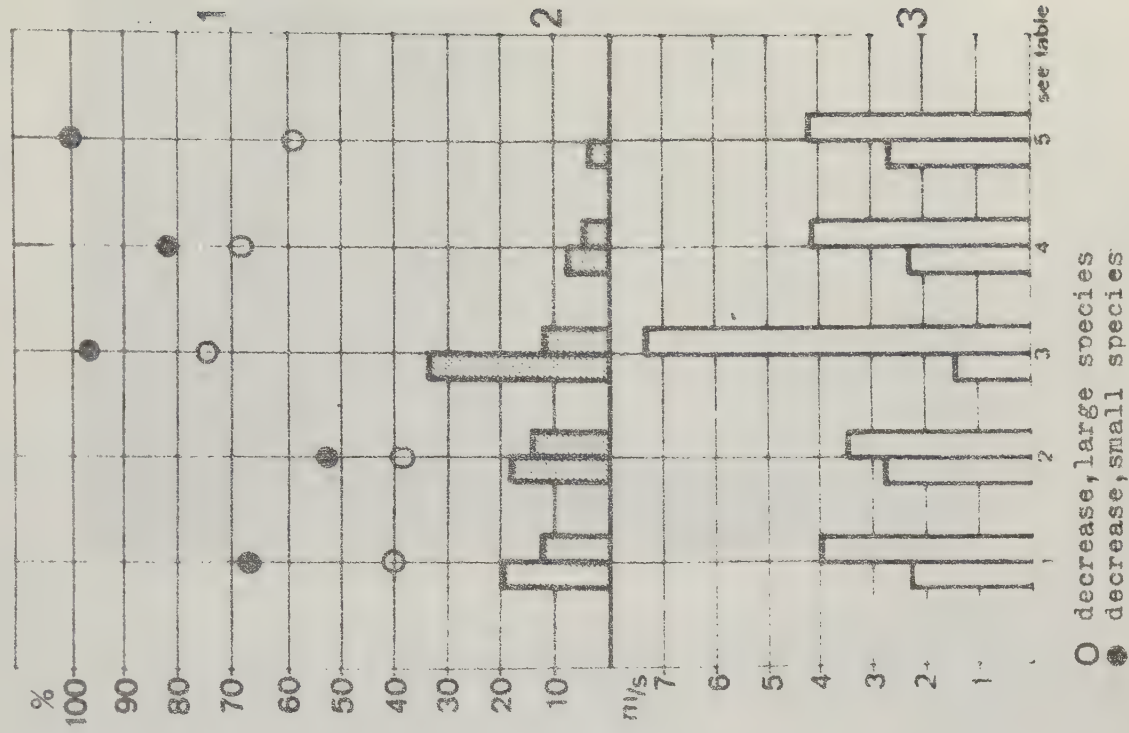


FIG.59

DECREASE IN THE CATCH OF LARGE AND SMALL SPECIES ON SOME WINDY NIGHTS IN 1968



1 = decrease in catch in per cent of the catch the night before  
 2 = per cent small species in the catch.  
 3 = mean night wind velocity.



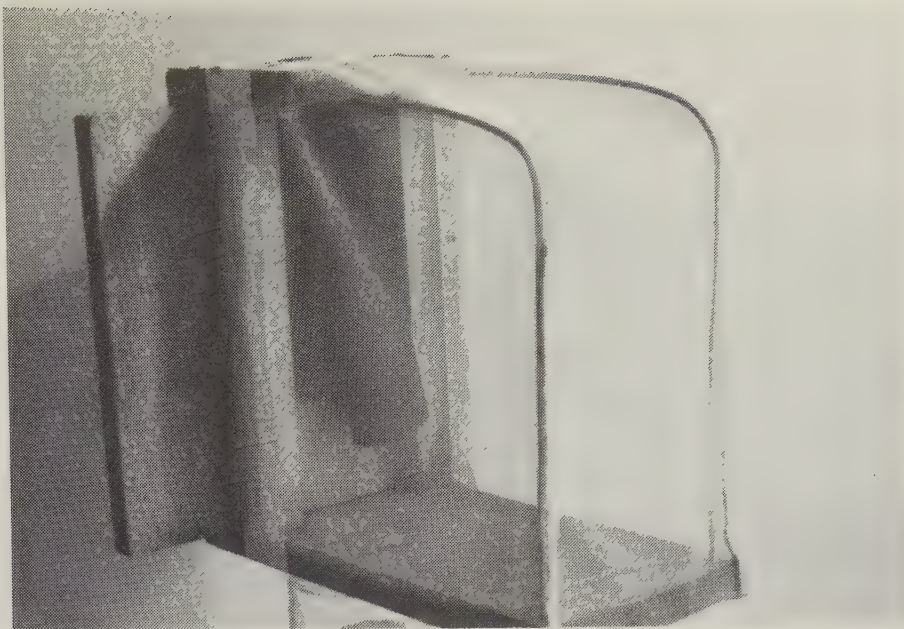


Fig.60 The type of cage used in the flight start controls. The moths are sheltered in dark cloth during daytime. All the cages were numbered and up to fifty cages could be used at the same time.

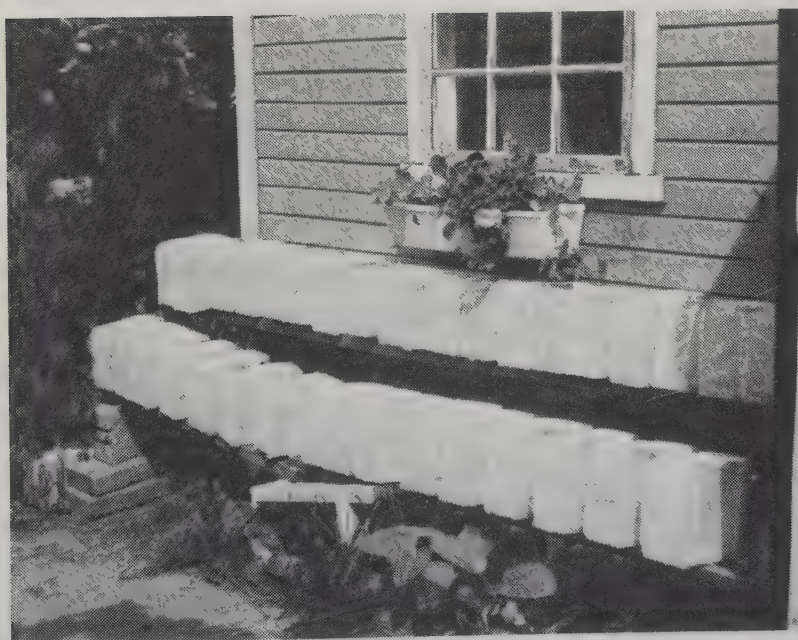


Fig.61 The arrangement of cages during the flight start observations. The wall behind the cages is directed against NW. Only the late afternoon sun hits the cages. The temperature and humidity in the cages were continuously controlled.

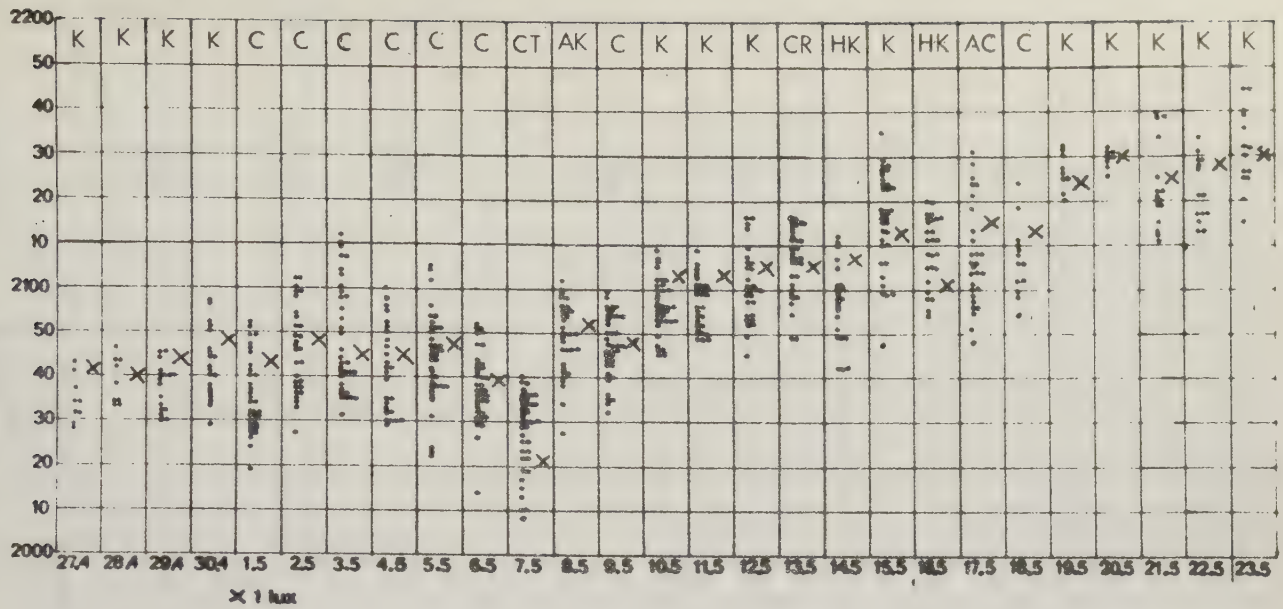




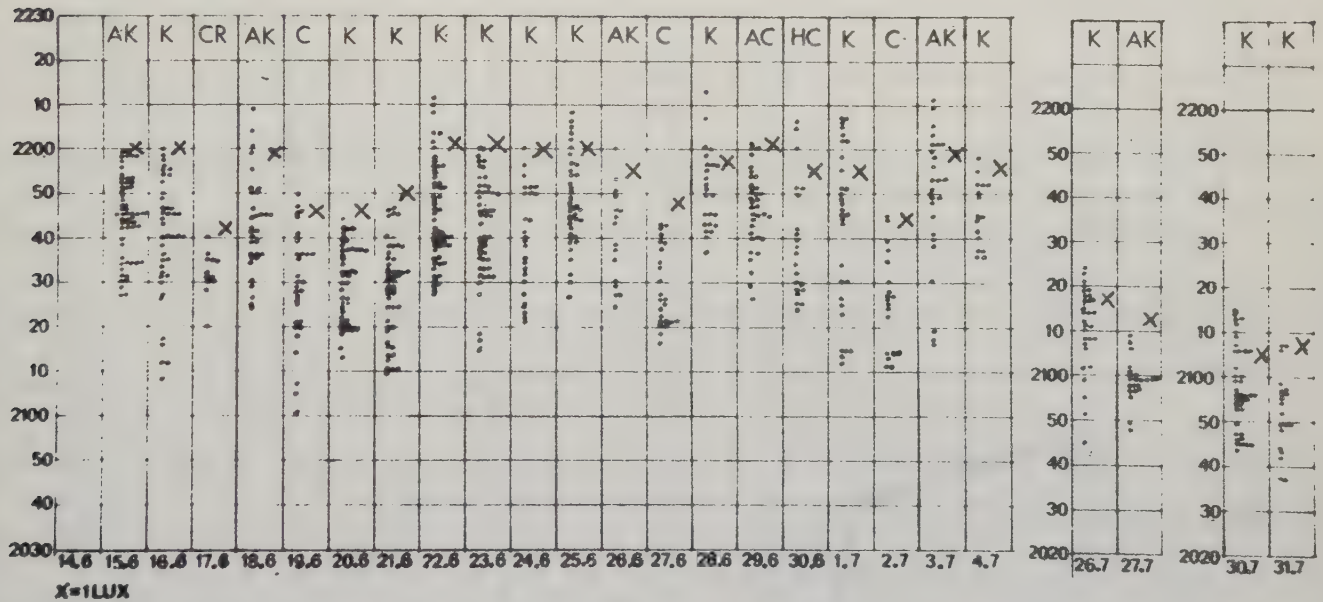
FIG.62

## START OF FLIGHT

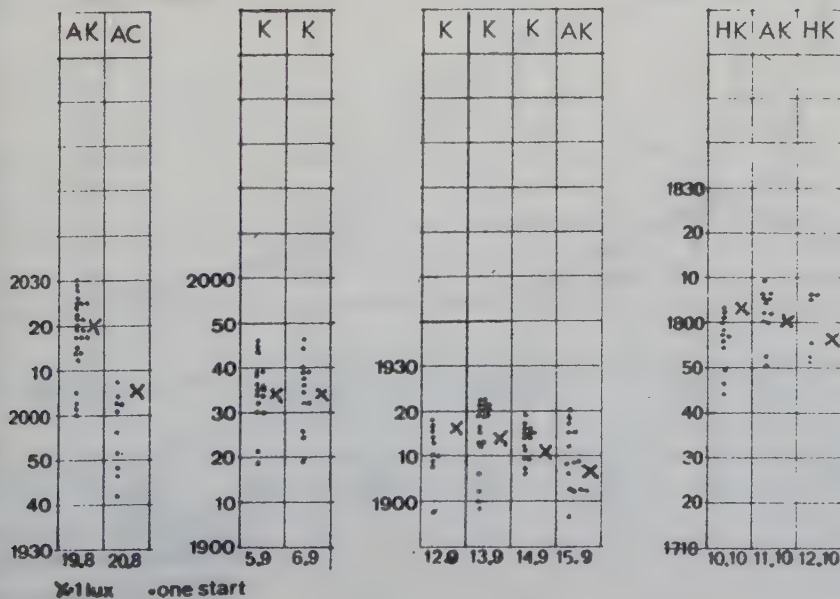
## SPRING



## SUMMER



## AUTUMN



- K clear sky
- C cloudy
- HC halfcloudy
- AC almost cloudy
- CT cloudy,thunder
- CR cloudy,rain



Fig.63 DISTRIBUTION OF FLIGHT STARTS ON LUX-AREAS

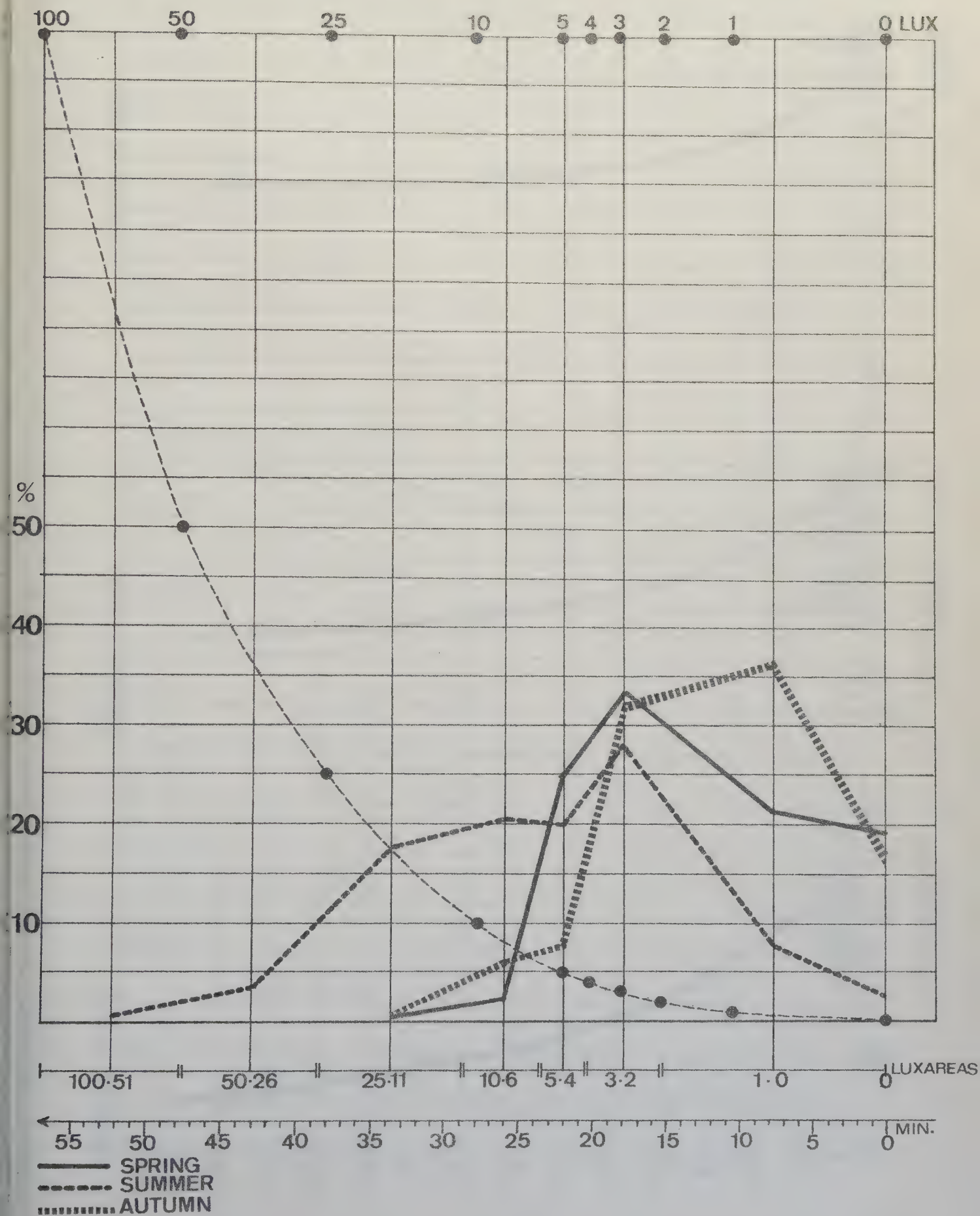






Fig.64 START OF FLIGHT ON THREE SELECTED NIGHTS IN RELATION TO THE LIGHT

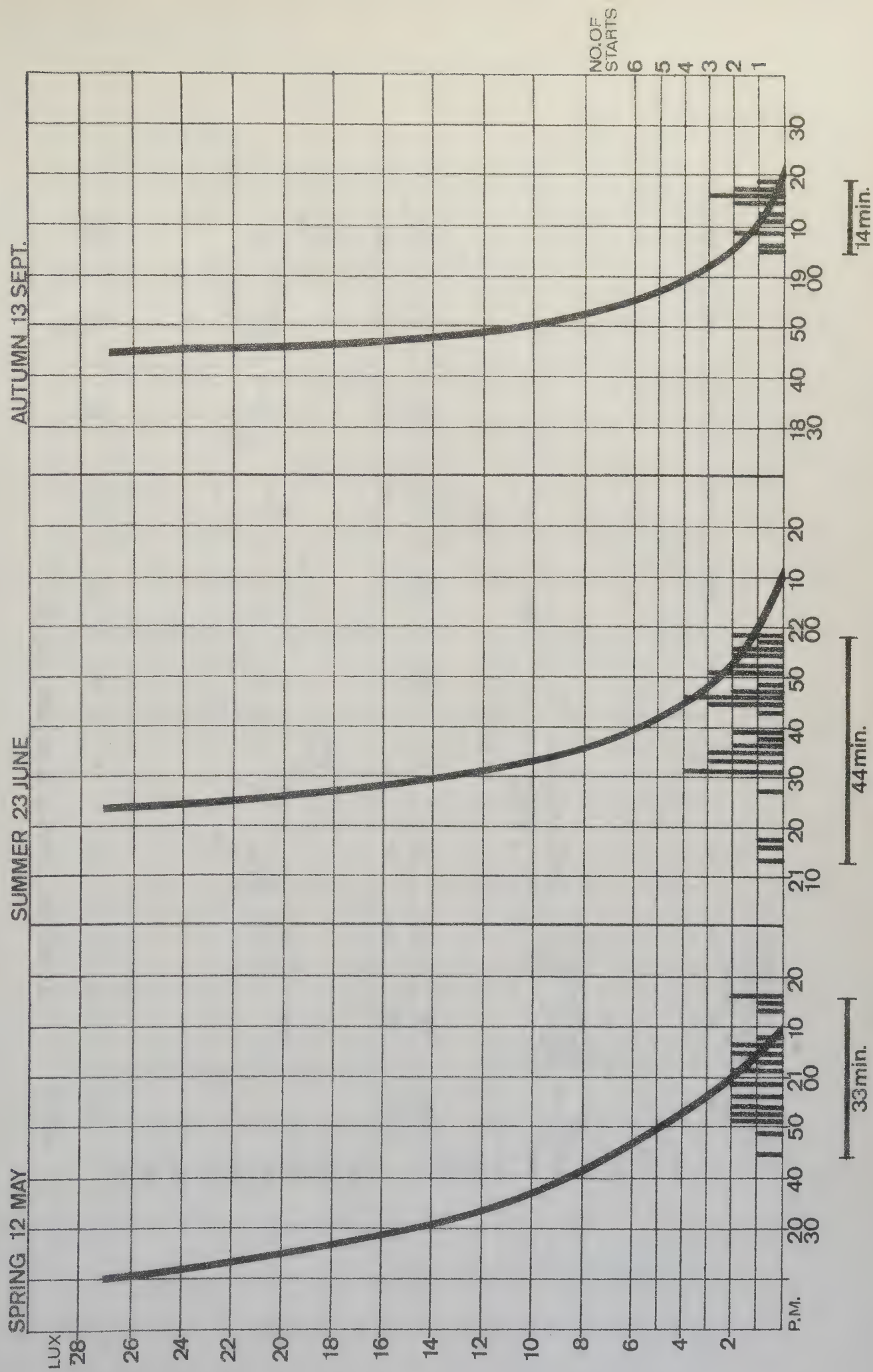




FIG.65 START OF FLIGHT, MONIMASPECIES

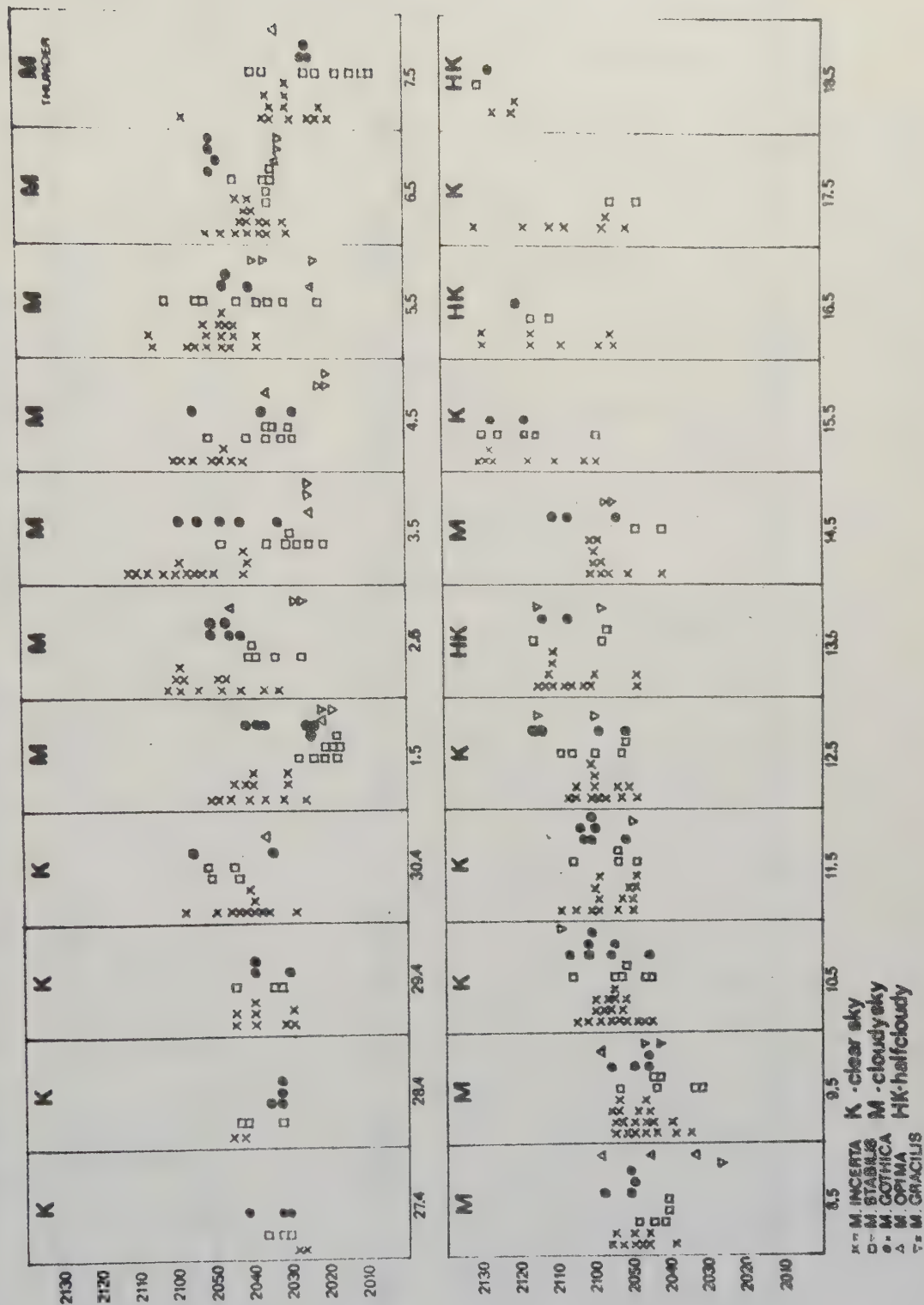






FIG.66 START OF FLIGHT OF SOME SPECIMENS IN RELATION TO THE LIGHT

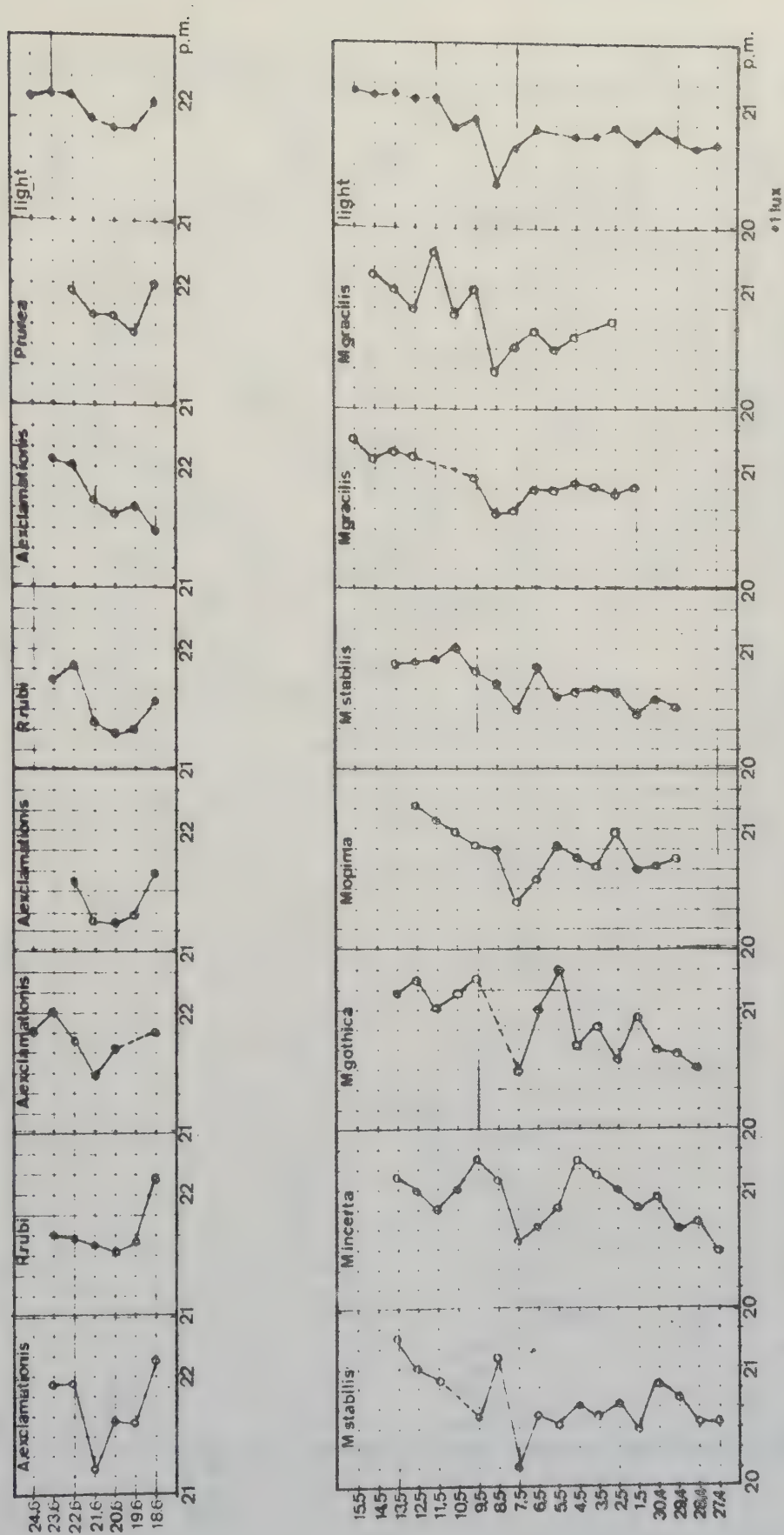




FIG. 67  
START OF FLIGHT IN RELATION TO WEATHER FACTORS

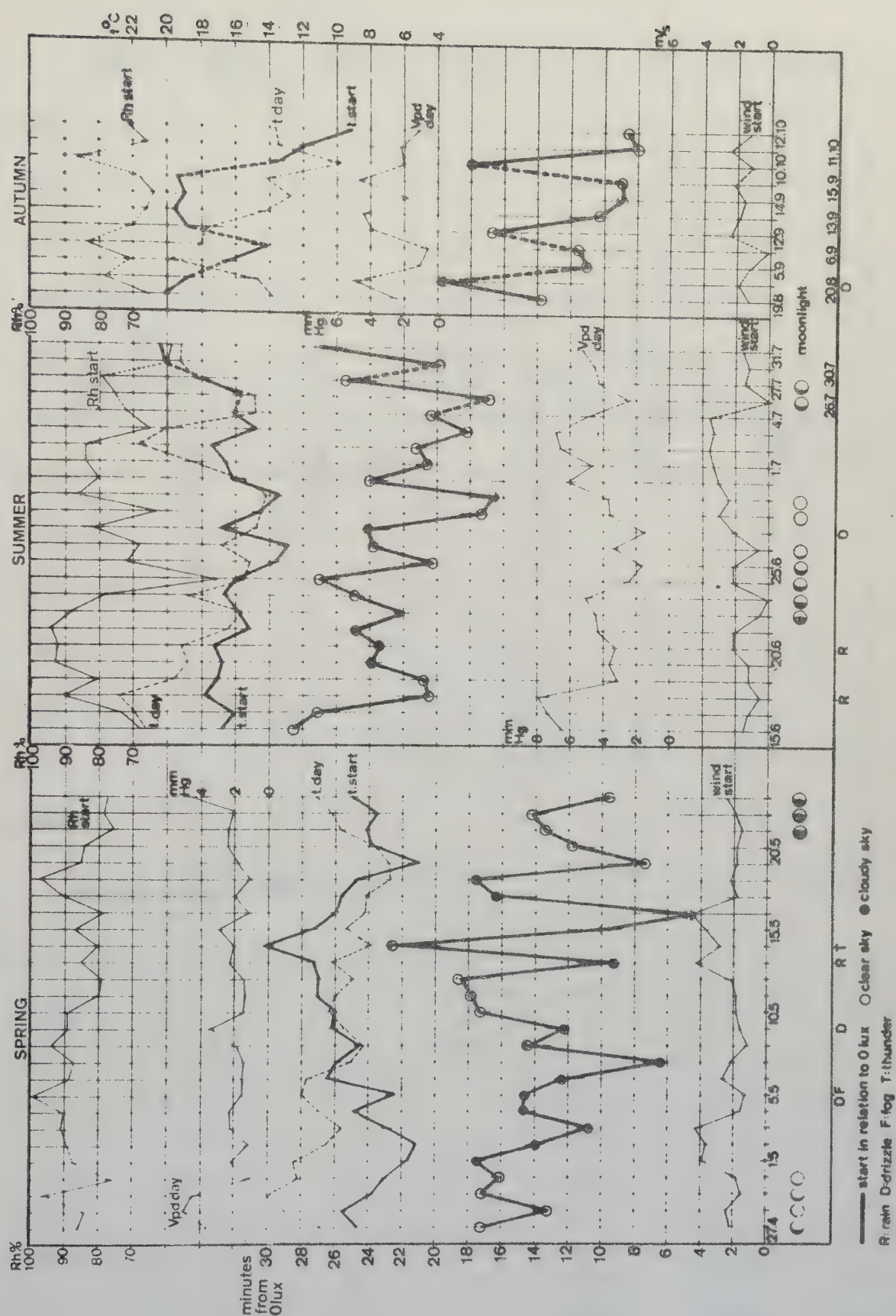
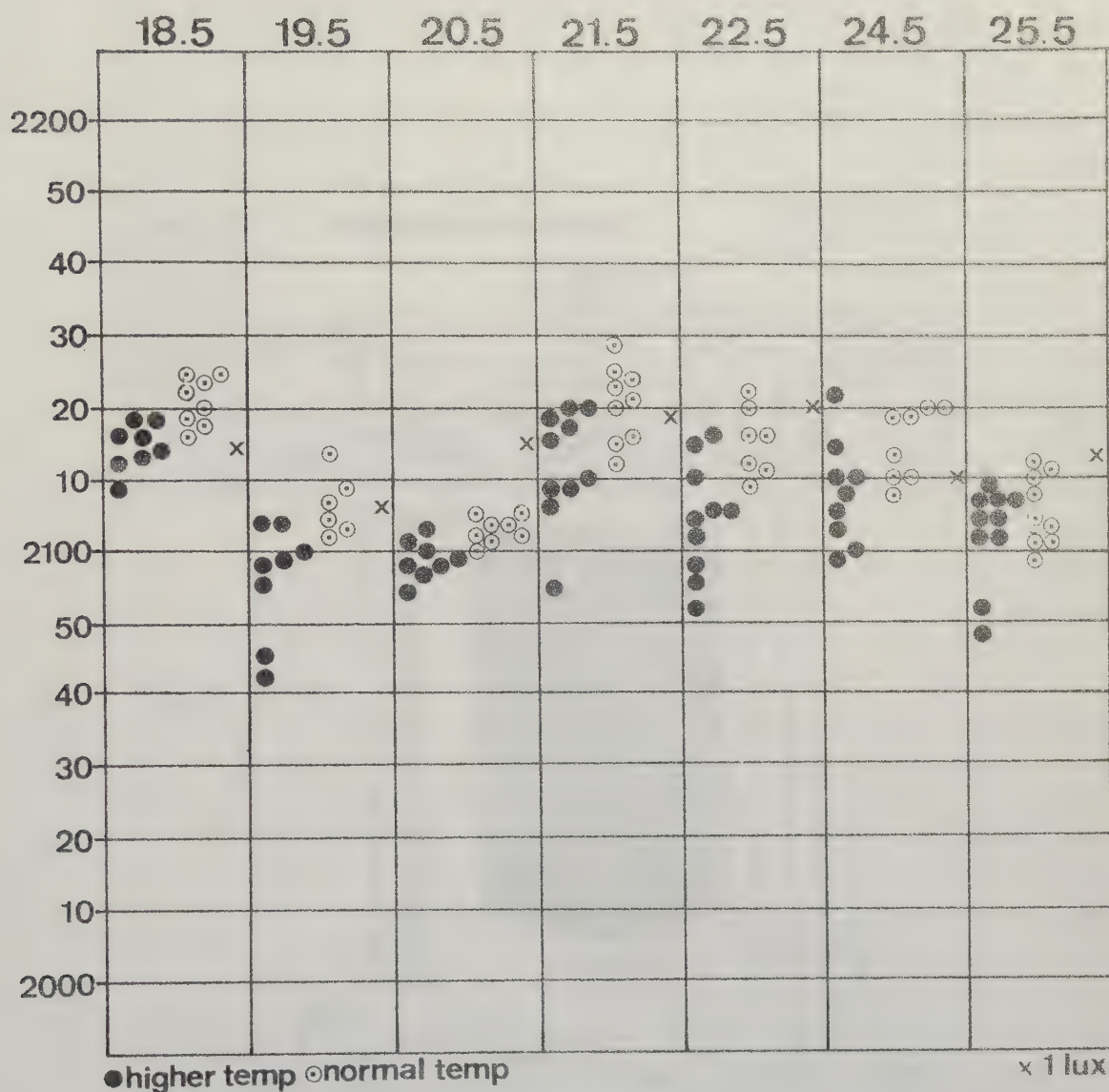






Fig.68

## START OF FLIGHT IN RELATION TO TEMPERATURE

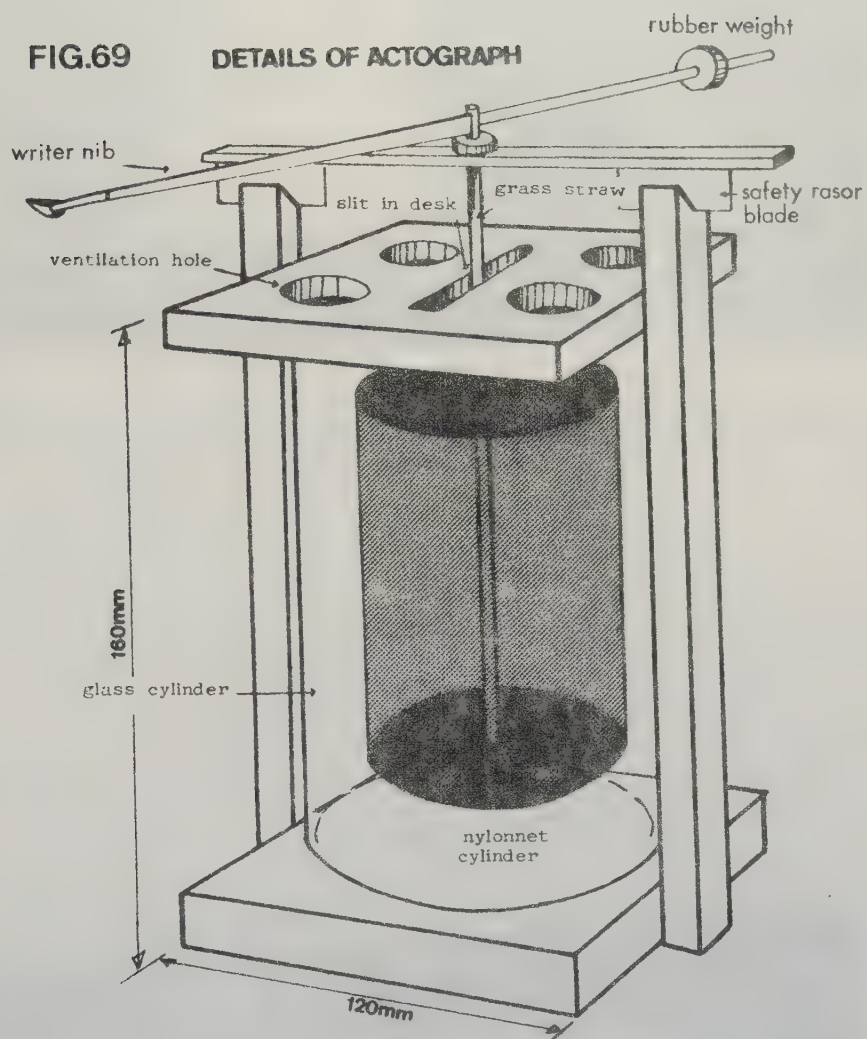


| date | outside temp. °C | temp. in heated cages | outside Rh % | Rh in heated cages | sky         | t-value of diff. | sign. of diff. P |
|------|------------------|-----------------------|--------------|--------------------|-------------|------------------|------------------|
| 18.5 | 8.5              | 15.0-17.0             | 92           | 72                 | clear       | 3.81             | 0.01-0.001       |
| 19.5 | 7.1              | 15.0-17.0             | 97           | 67                 | cloudy      | 2.81             | 0.02-0.01        |
| 20.5 | 9.8              | 15.0-17.0             | 92           | 56                 | half-cloudy | 3.51             | 0.01-0.001       |
| 21.5 | 8.1              | 15.0-17.0             | 87           | 52                 | clear       | 2.92             | 0.02-0.01        |
| 22.5 | 8.0              | 15.0-17.0             | 90           | 55                 | clear       | 4.92             | 0.001            |
| 24.5 | 8.7              | 15.0-17.0             | 87           | 53                 | cloudy      | 2.26             | 0.05-0.02        |
| 25.5 | 13.3             | 15.0-17.0             | 75           | 68                 | cloudy      | 1.18             | 0.30-0.20        |



FIG.69

DETAILS OF ACTOGRAPH







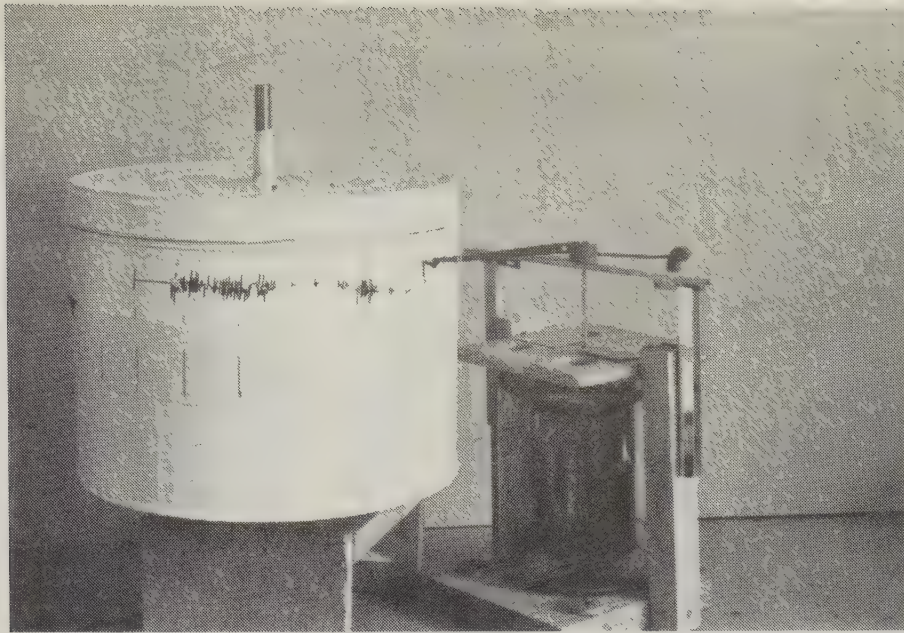


Fig.70 The actograph with the registration drum. The drum makes a complete revolution in 24 hours.

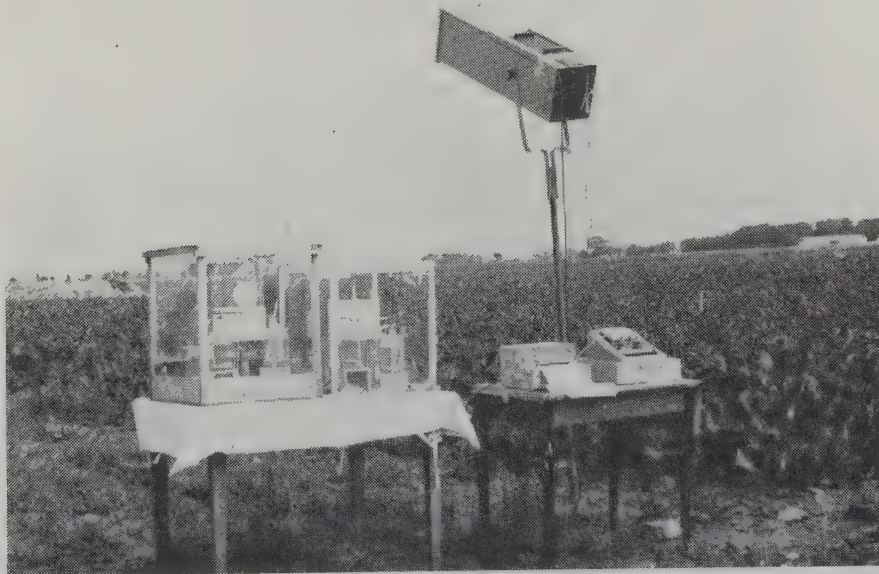


Fig.71 The equipment for observations of the moon light and normal night light. The two glass boxes with actographs are visible on the table to the left and the microphotometer and the recorder to the right. The tube with the fotocell head can be seen above the microphotometer. The landscape is open and all parts of the sky is accessible to observations.



FIG.72

NIGHT-LIGHT EXPERIMENTS, JUNE 1970

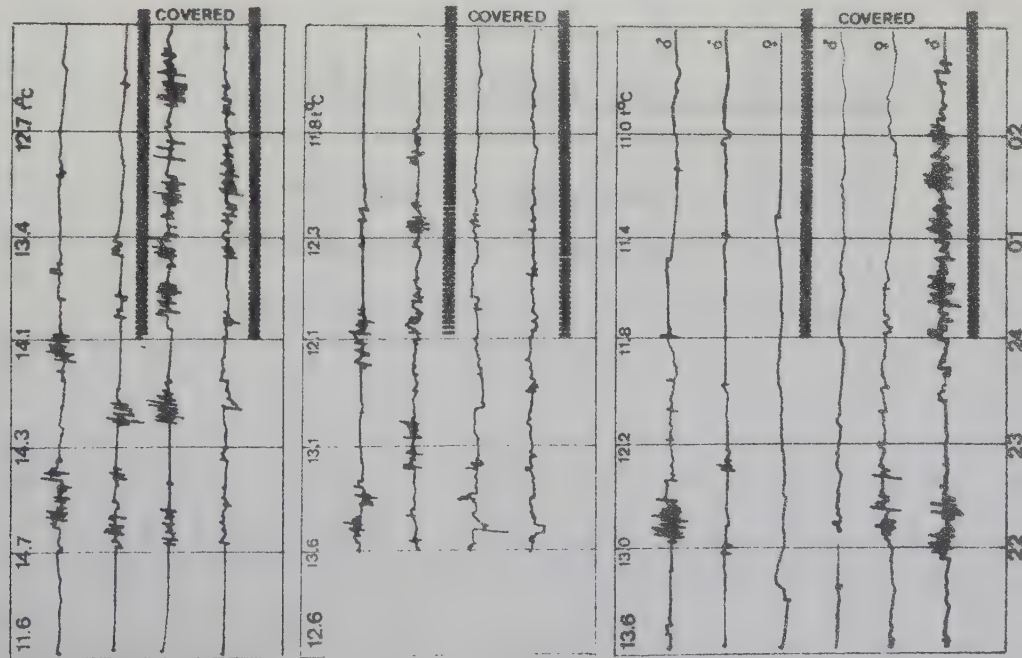


FIG.73

NIGHT-LIGHT EXPERIMENTS, JUNE 1970

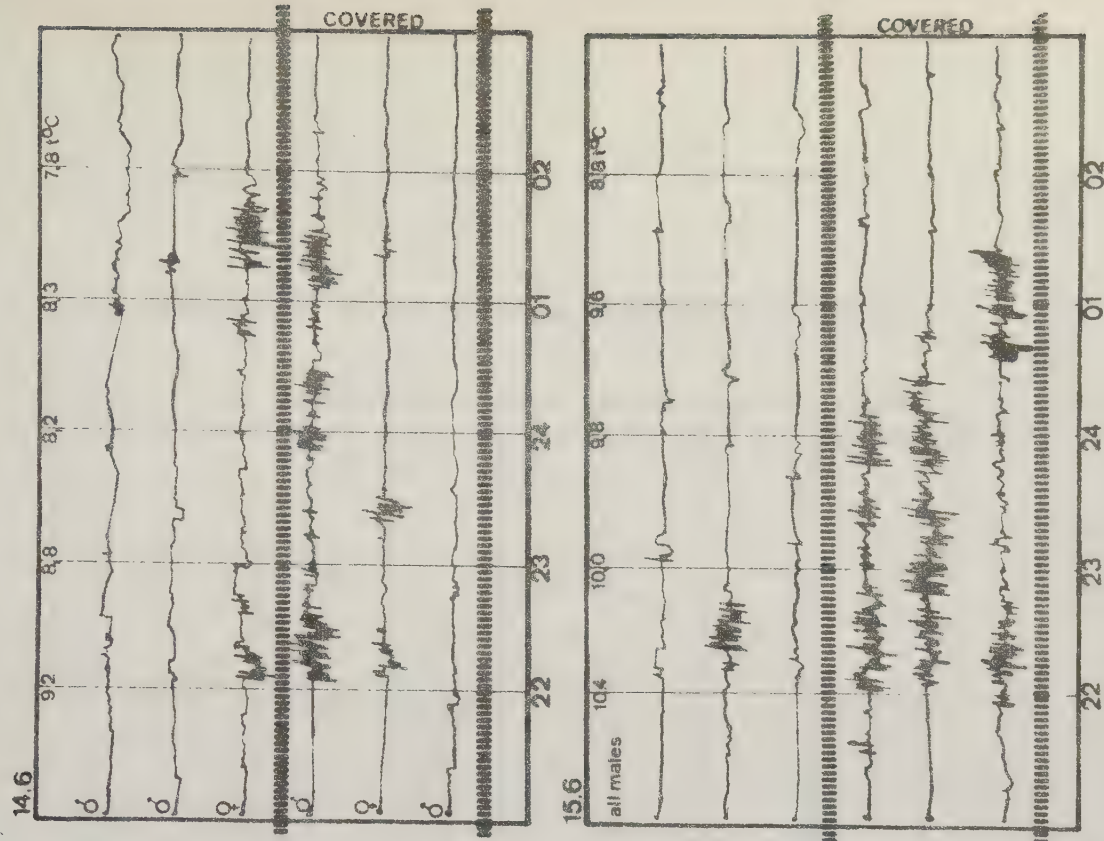








FIG.74

NIGHT LIGHT EXPERIMENT, JUNE 1970

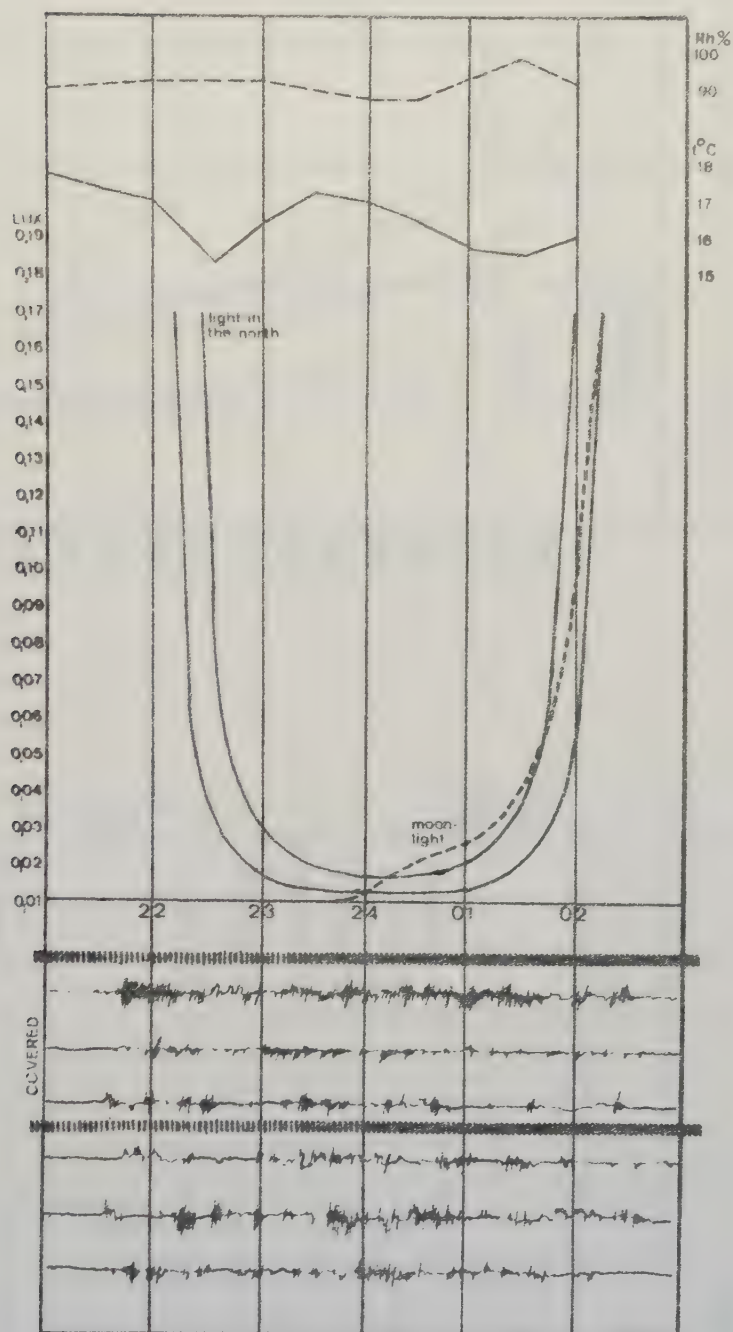




FIG.75

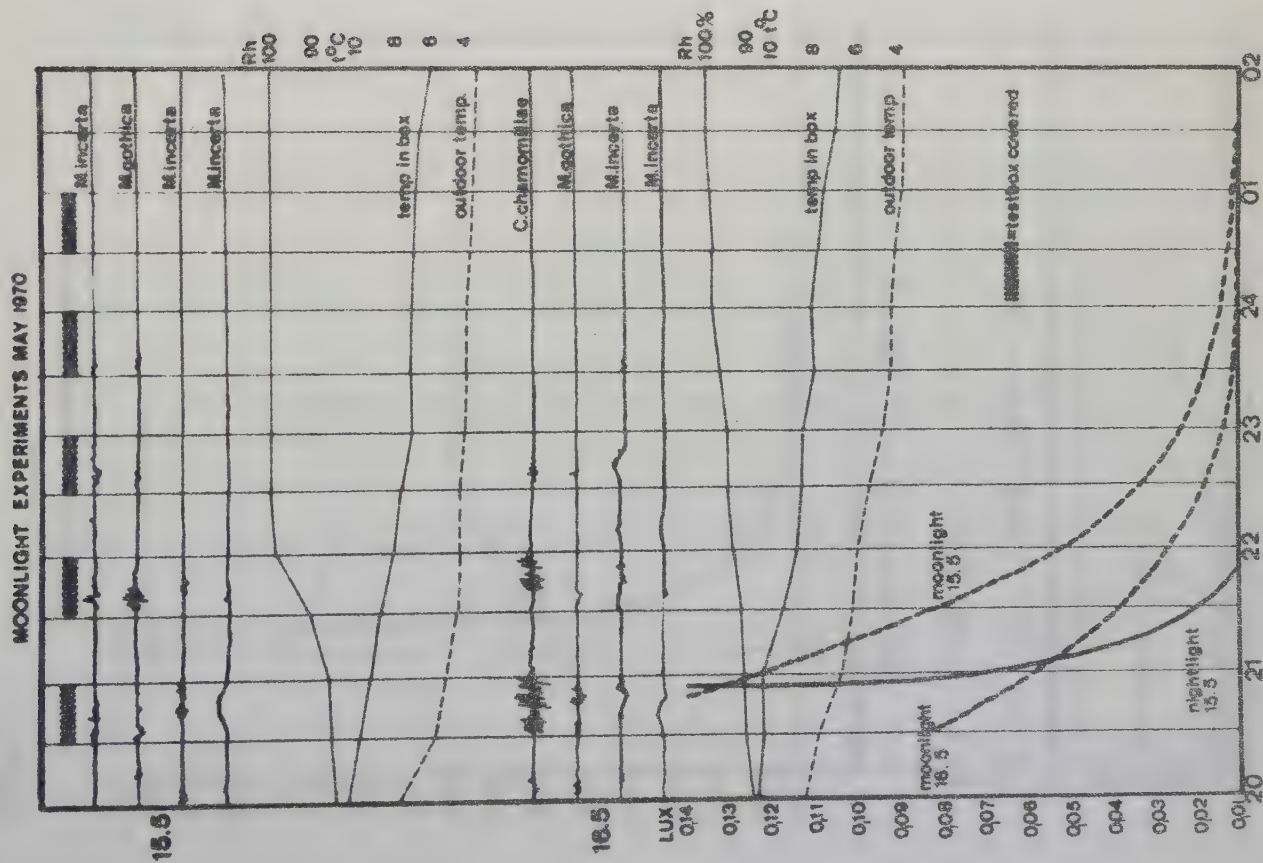


FIG.76

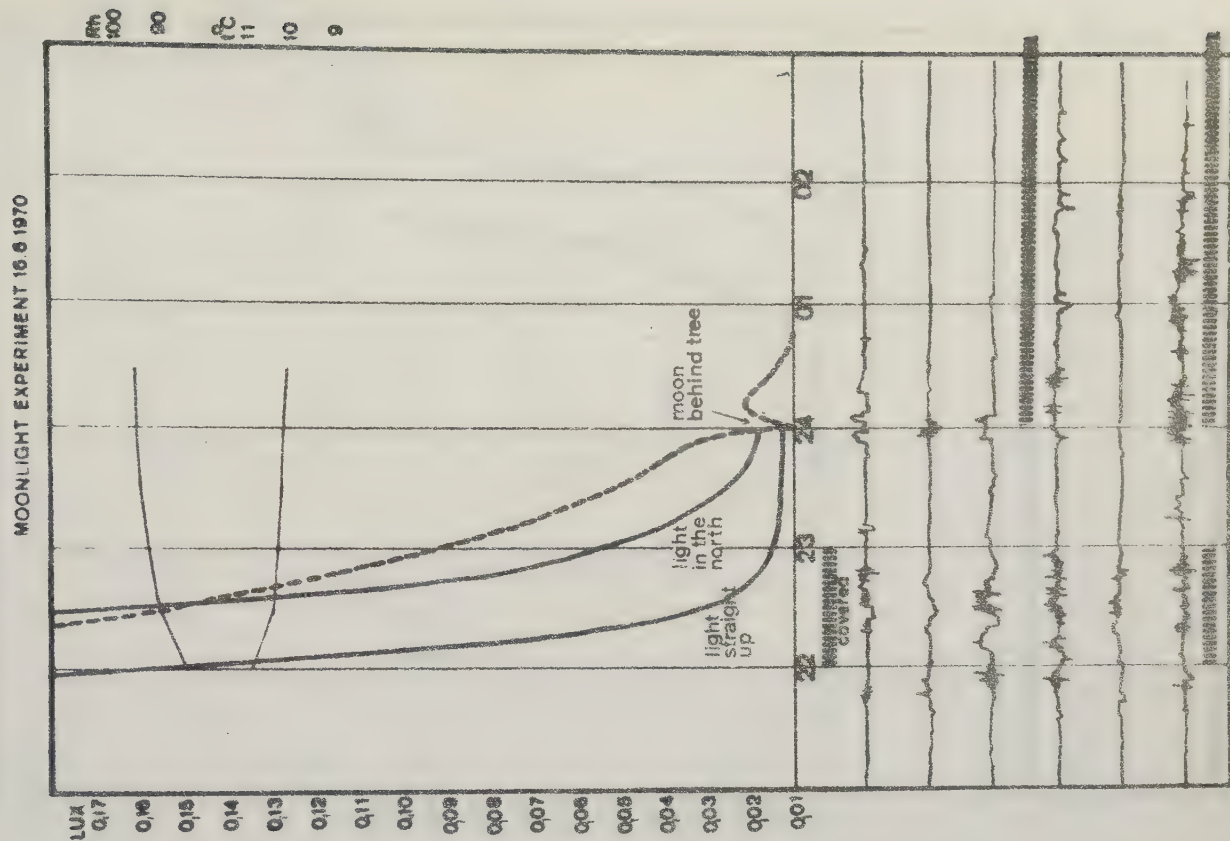






FIG.77

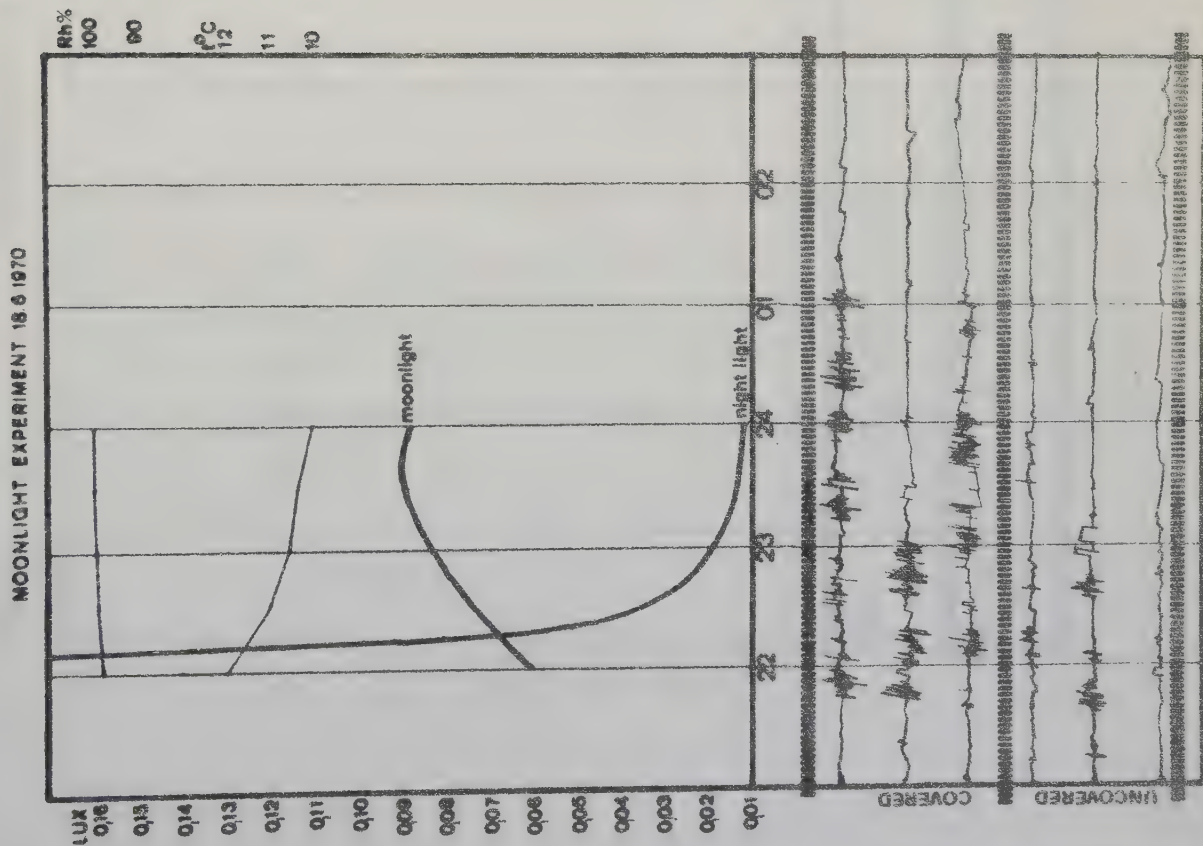
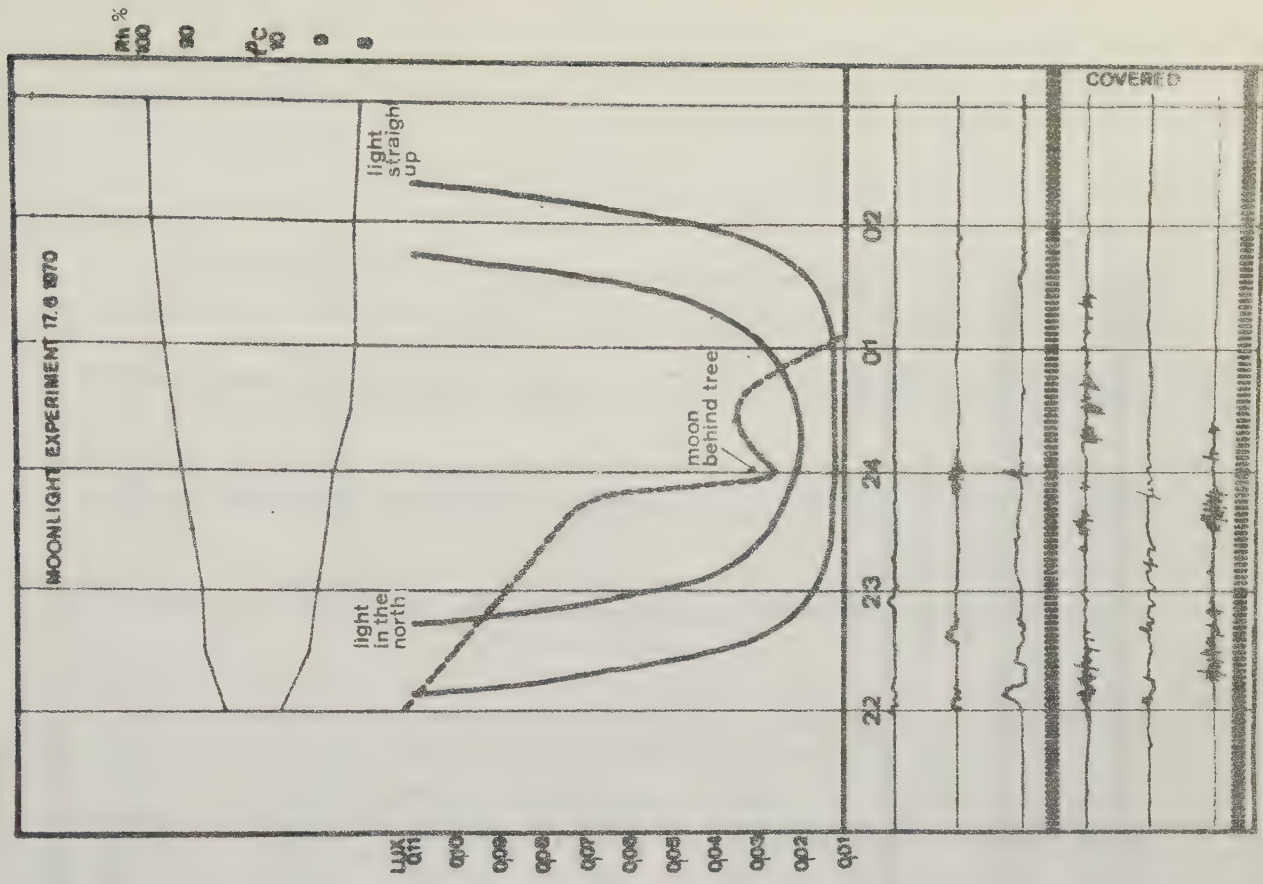


FIG.78





# MOONLIGHT EXPERIMENTS 1970

FIG.79

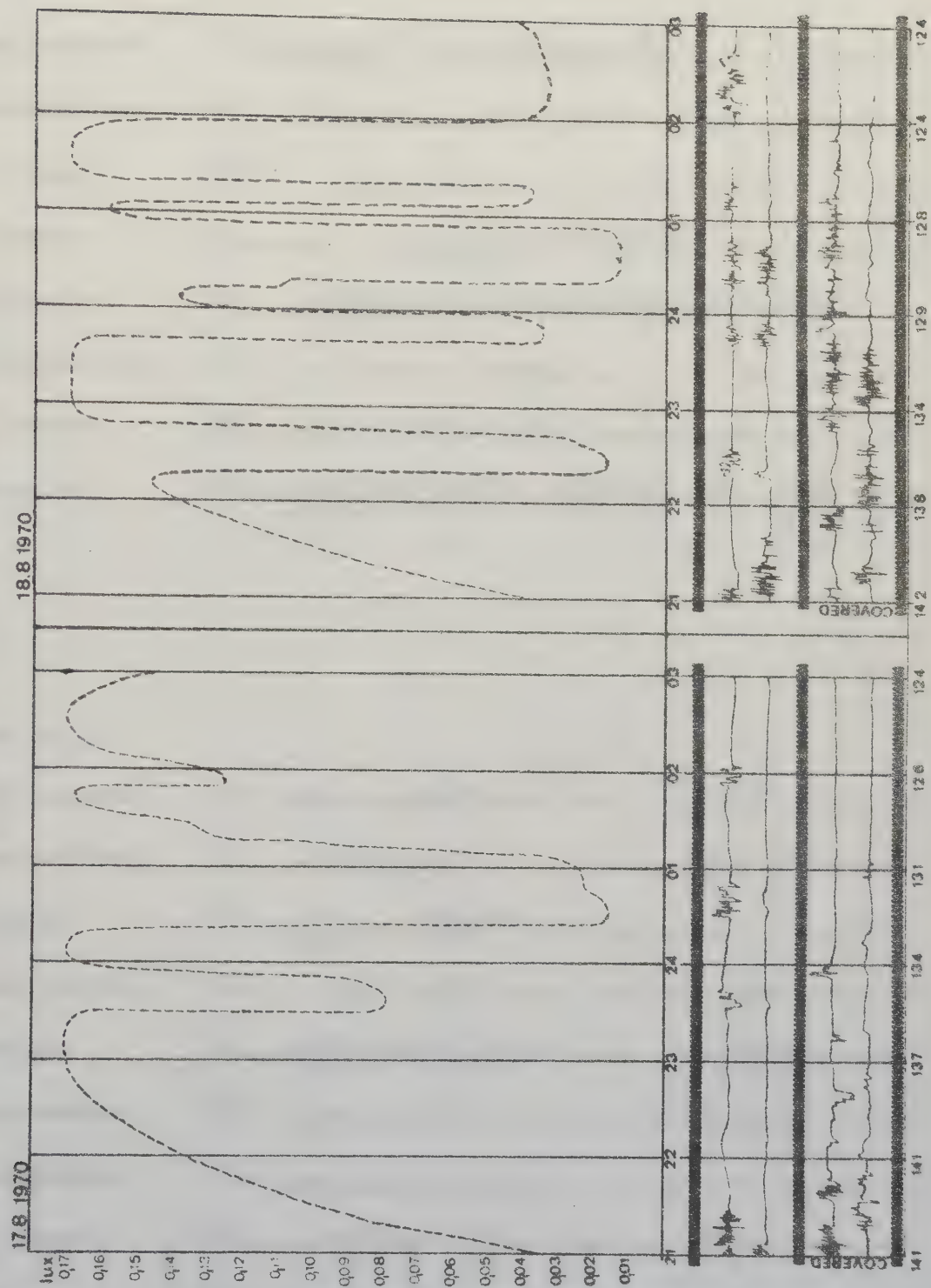
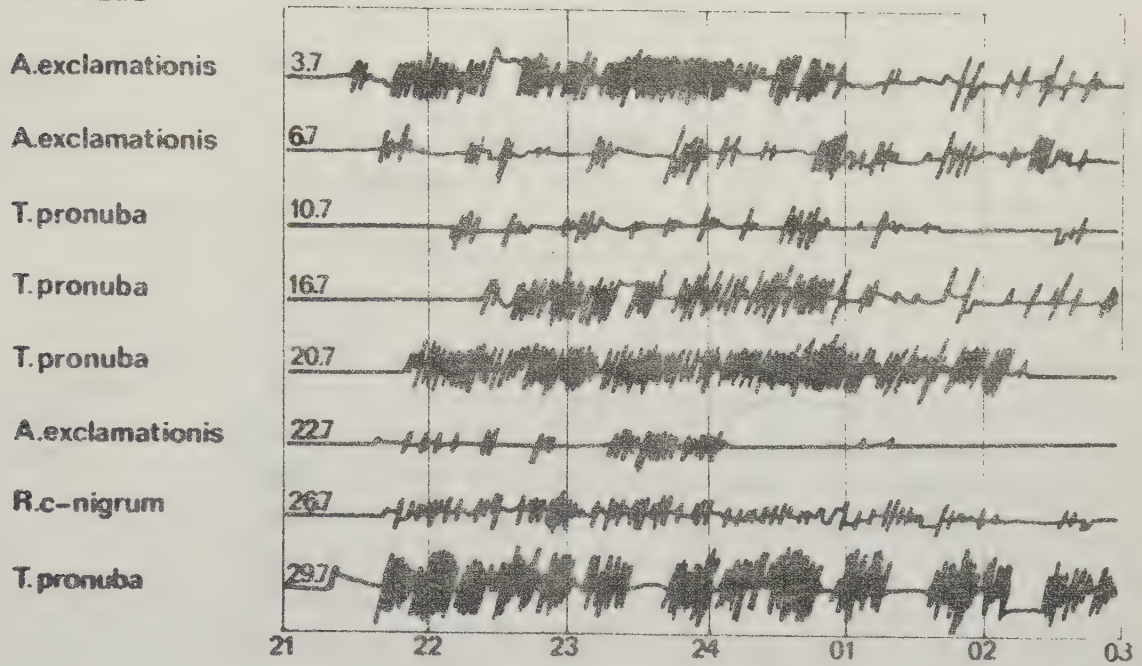






FIG.80 FLIGHT ACTIVITY IN SOME ACTOGRAPH EXPERIMENTS

A. MALES



B. FEMALES

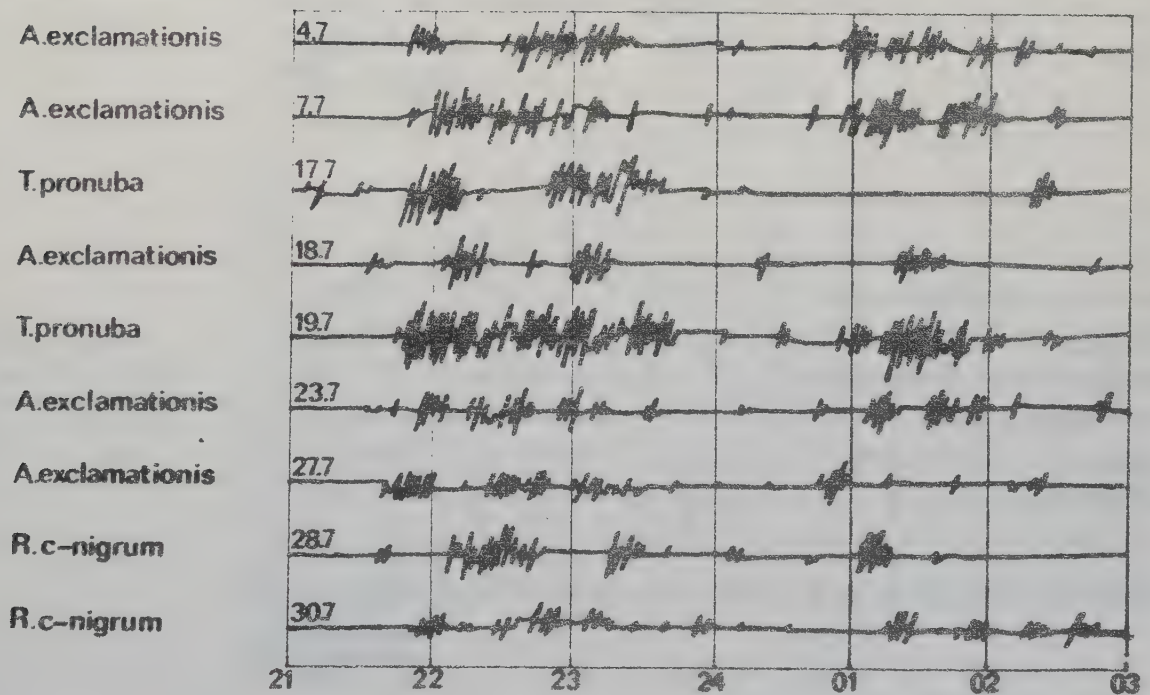
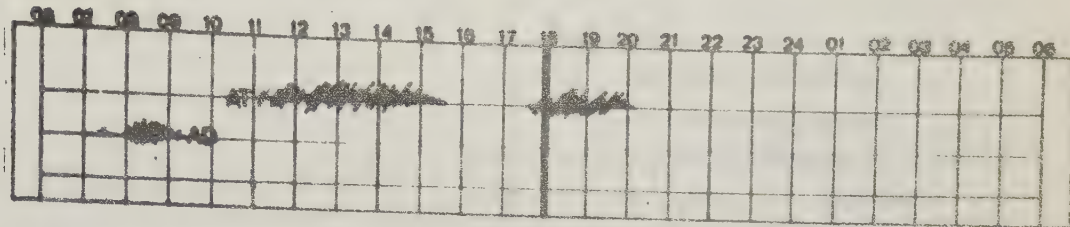




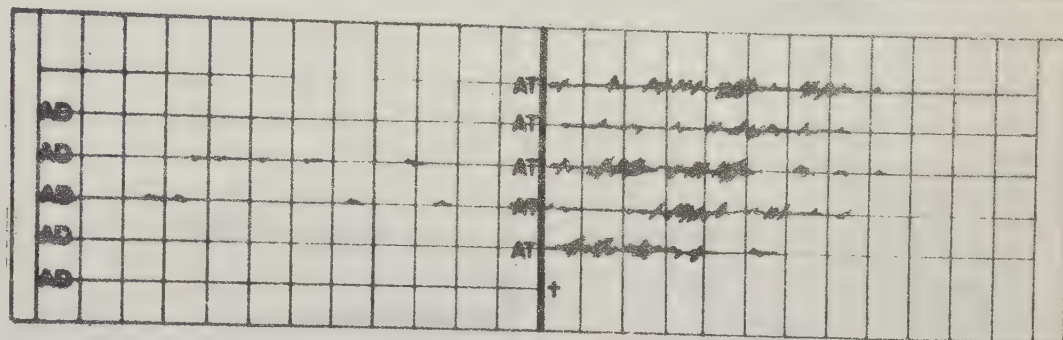
FIG.81

ACTOGRAPH EXPERIMENTS IN ARTIFICIAL LIGHT AND DARK CONDITIONS

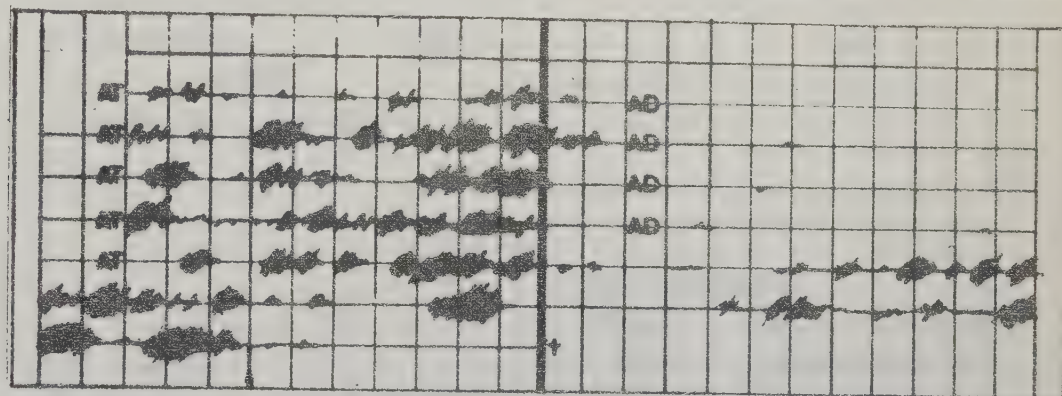
1. Artificial twilight and dawn in day-time



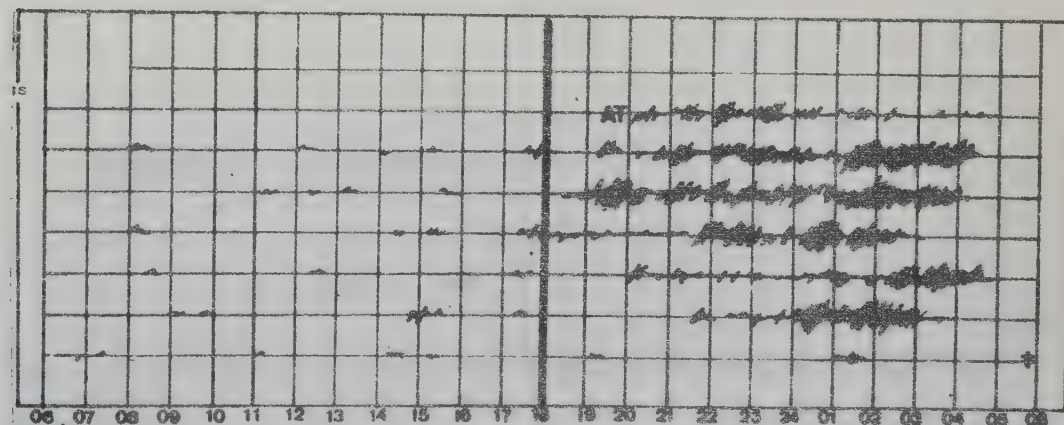
2. Normal rhythm: dark night light day



3. Changed rhythm: light night dark day, finally total darkness



4. One night and one day in light then total darkness



AT artificial twilight  
AD artificial dawn  
+ death

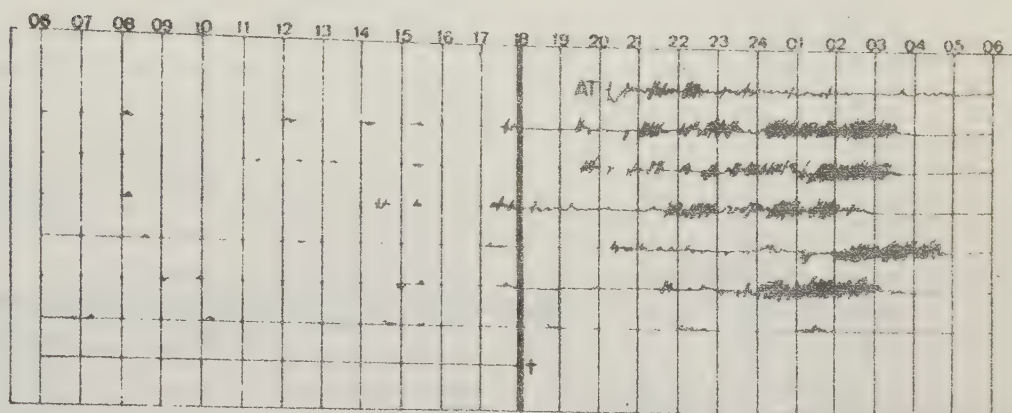




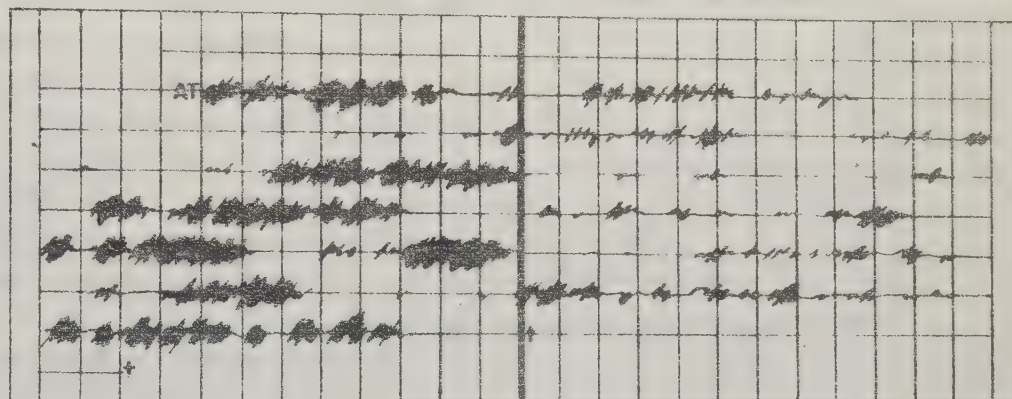
FIG.82

ACTOGRAPH EXPERIMENTS IN ARTIFICIAL LIGHT AND DARK CONDITIONS

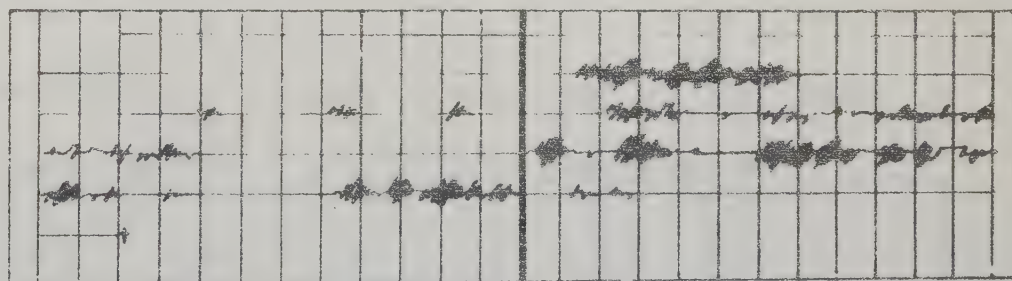
5. Twilight in the evening, then total darkness



6. One light night, then twilight in the morning then total darkness



7. Light all the time.



8. One light night then one dark day then light all the time

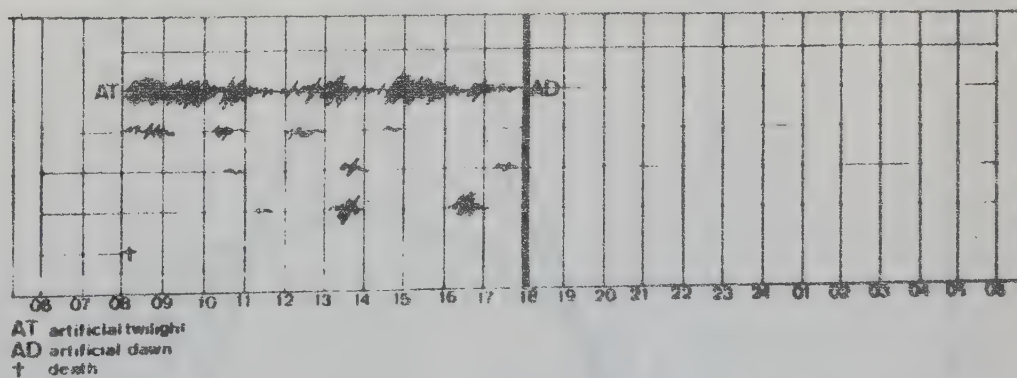




FIG.83

## ARTIFICIAL MOONLIGHT EXPERIMENTS, JULY 1970

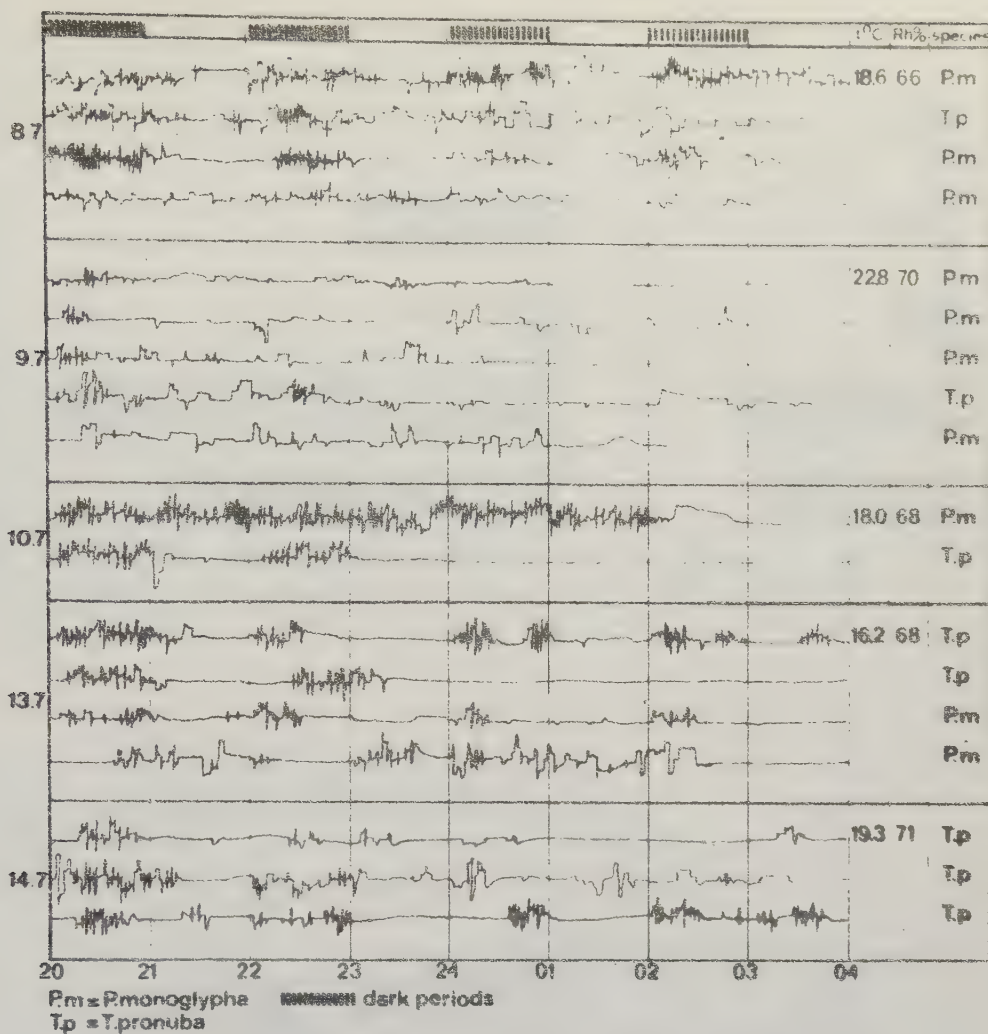


FIG.84

## NOCTURNAL DISTRIBUTION OF CATCH 1969, SMOOTHED CURVES

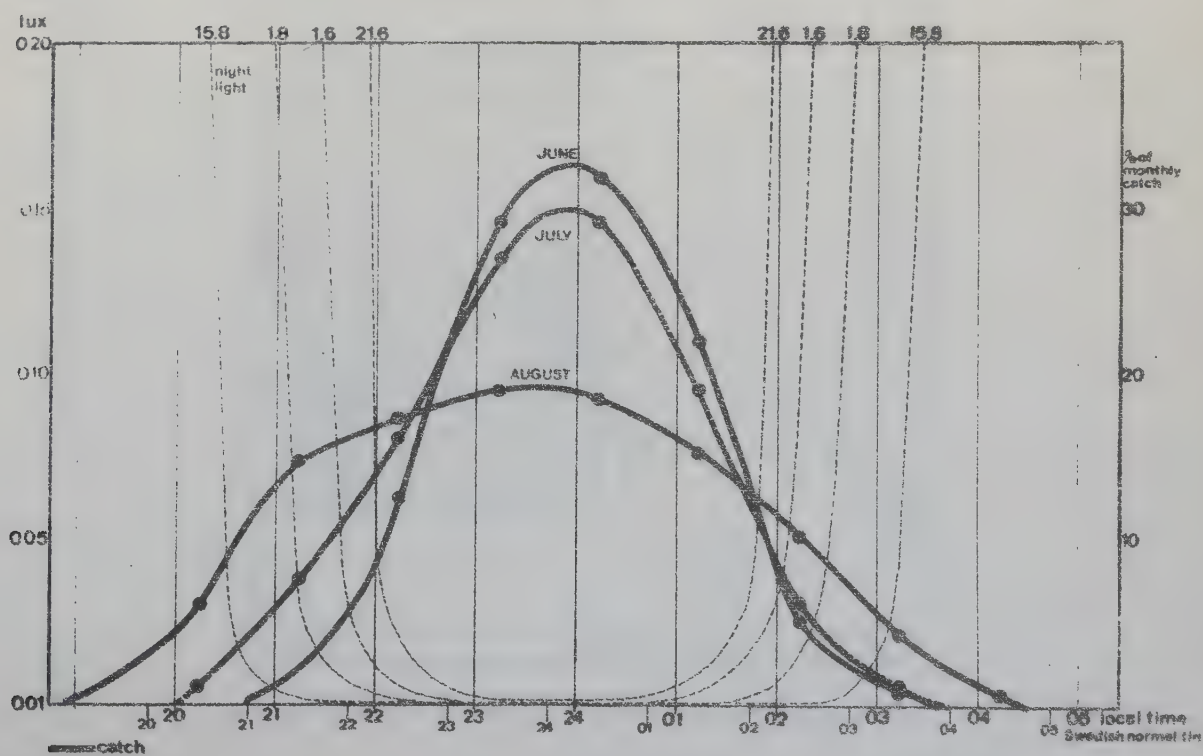






FIG.85

THE EGGLAYING RECORDING APPARATUS

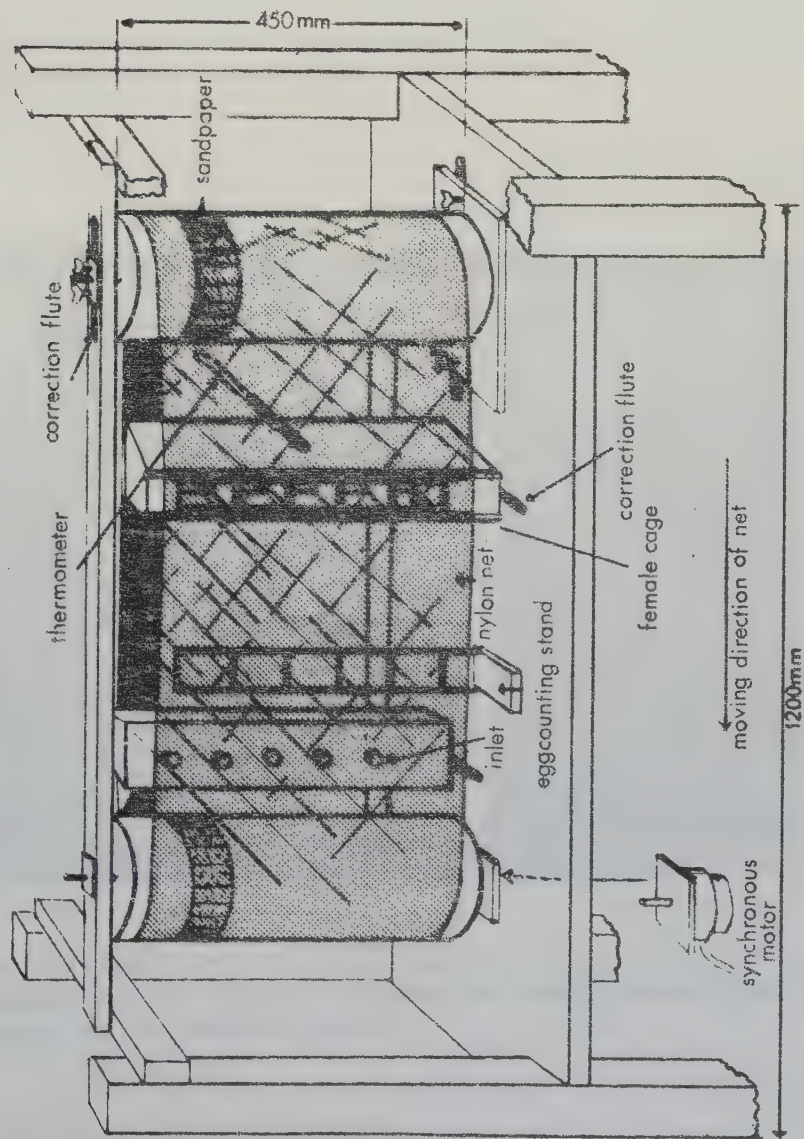
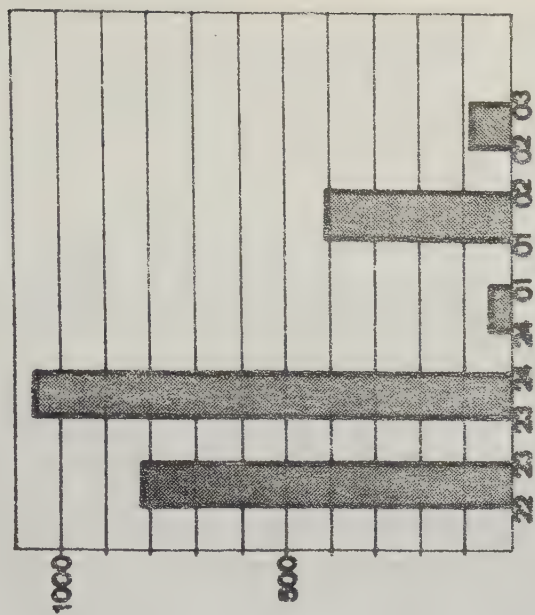
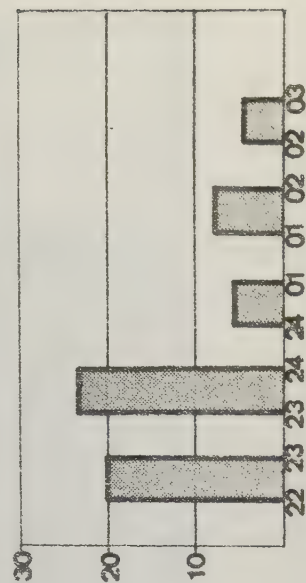


FIG.86

TOTAL NUMBER OF EGGS PER HOUR IN THE EGGLAYING RECORDING APPARATUS



EGGLAYING OCCASIONS PER HOUR







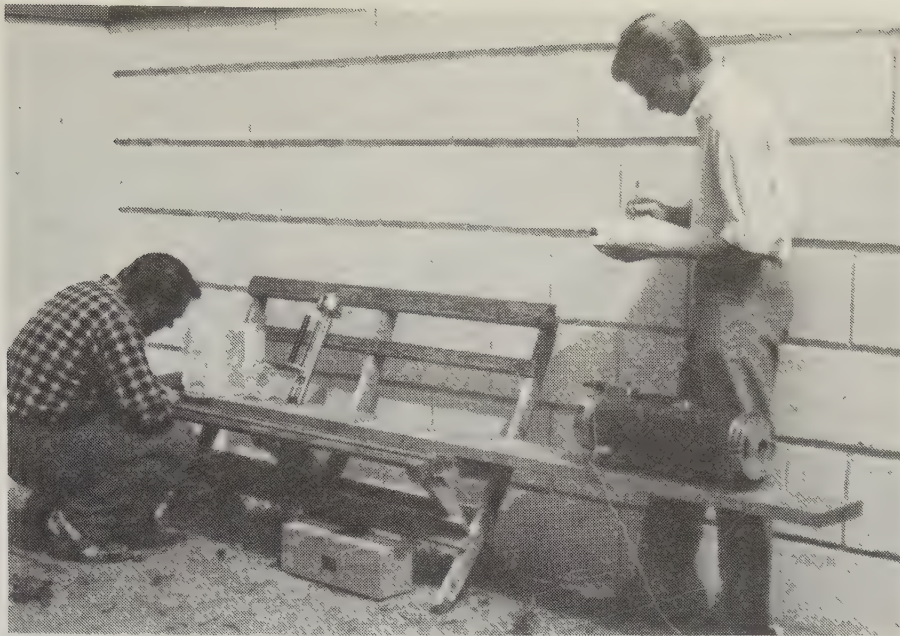


Fig.87 The wind velocity experiments. The vacuum cleaner blows an air current against the moth in the cage. The white lines on the plank mark different wind velocities. The anemometer covered by nylon net and the psychrometer were used for controls. The experiments took place at night.



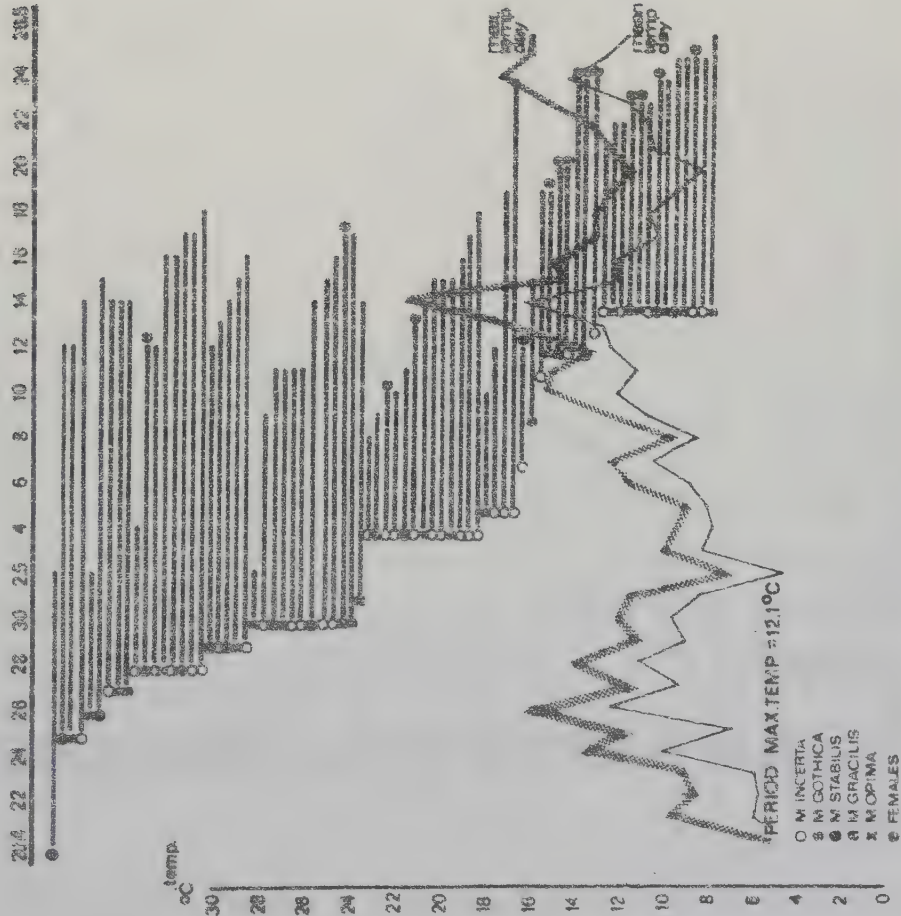
Fig.88 The egg-laying recording apparatus. The lid could be closed and the plastic curtains drawn around the apparatus in case of rain.



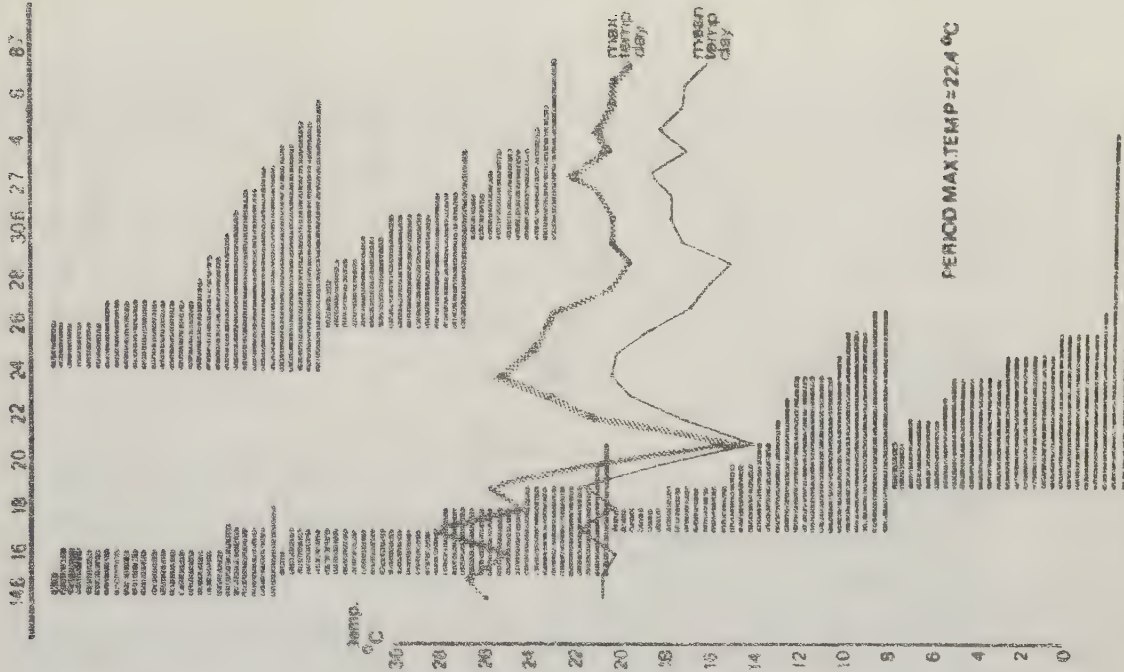


FIG.89

# LIFETIME AFTER CAPTURE, SPRING MEAN 11.8 DAYS



# LIFETIME AFTER CAPTURE, SUMMER MEAN 4.2 DAYS





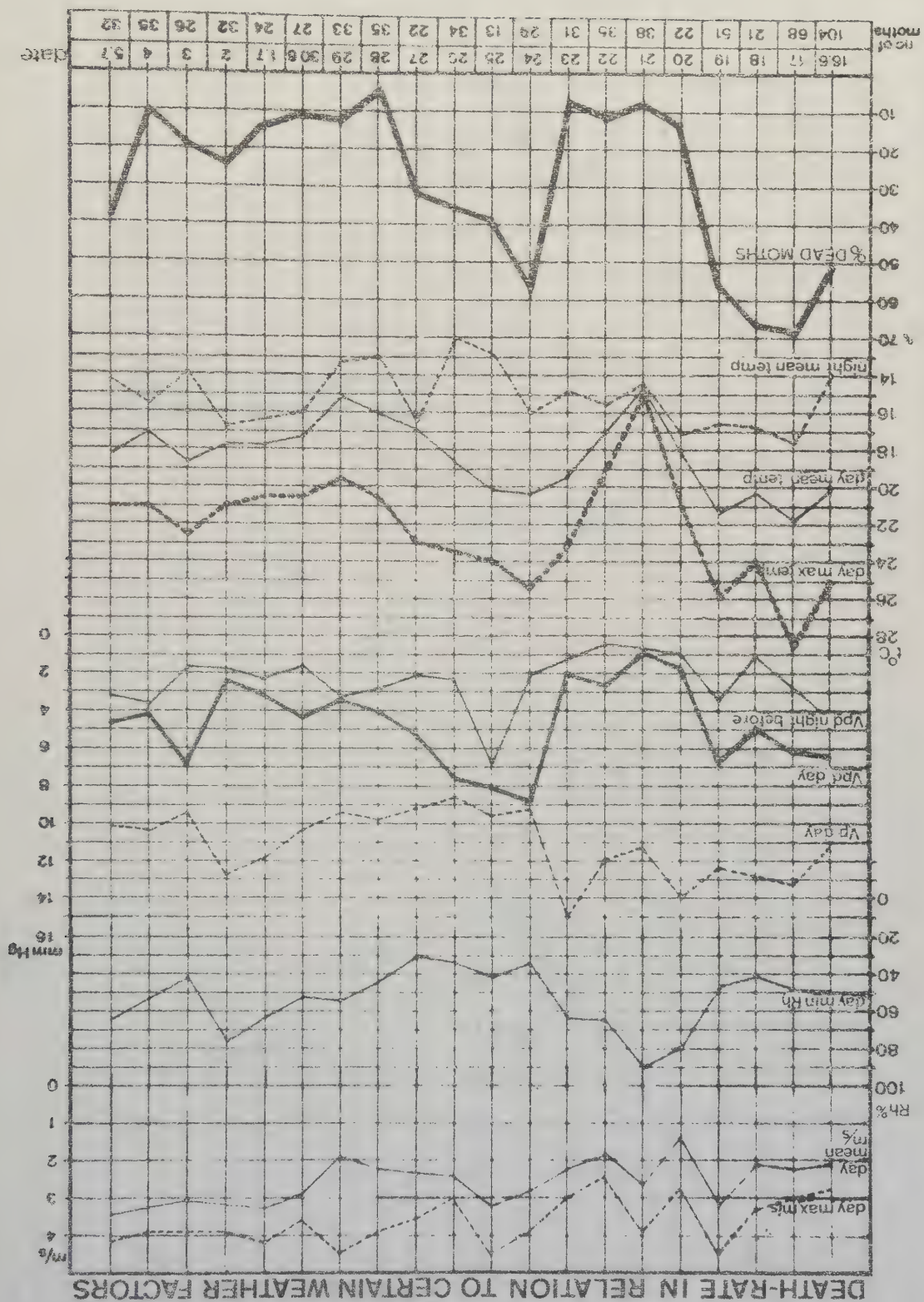


FIG. 90





FIG.91

DEATH-RATE IN RELATION TO THE DAY MEAN TEMPERATURE

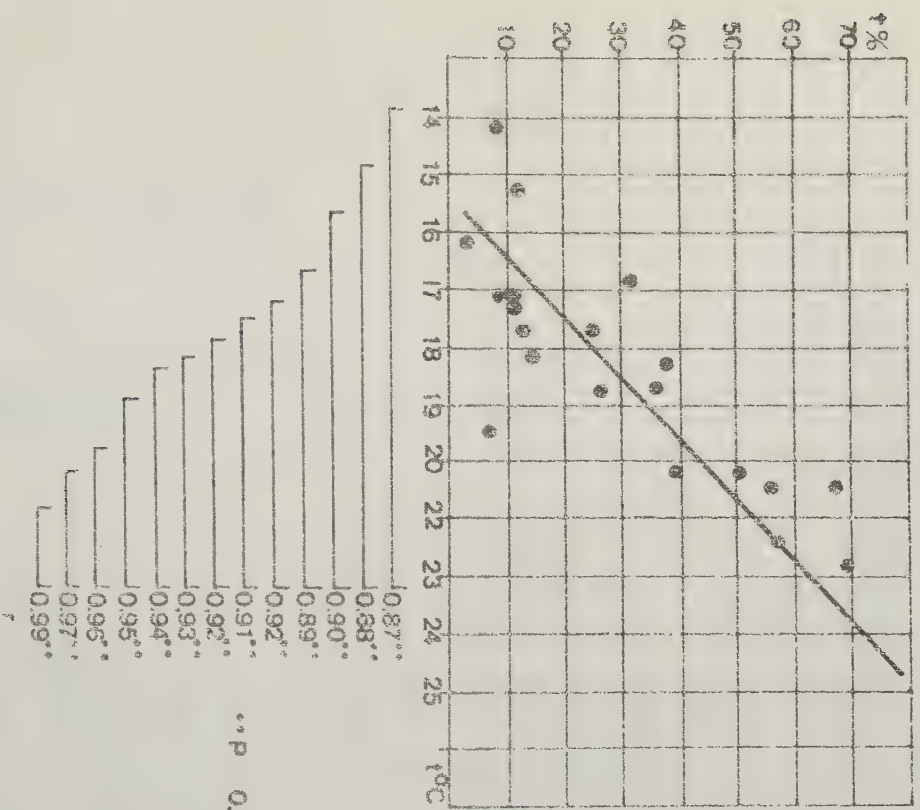
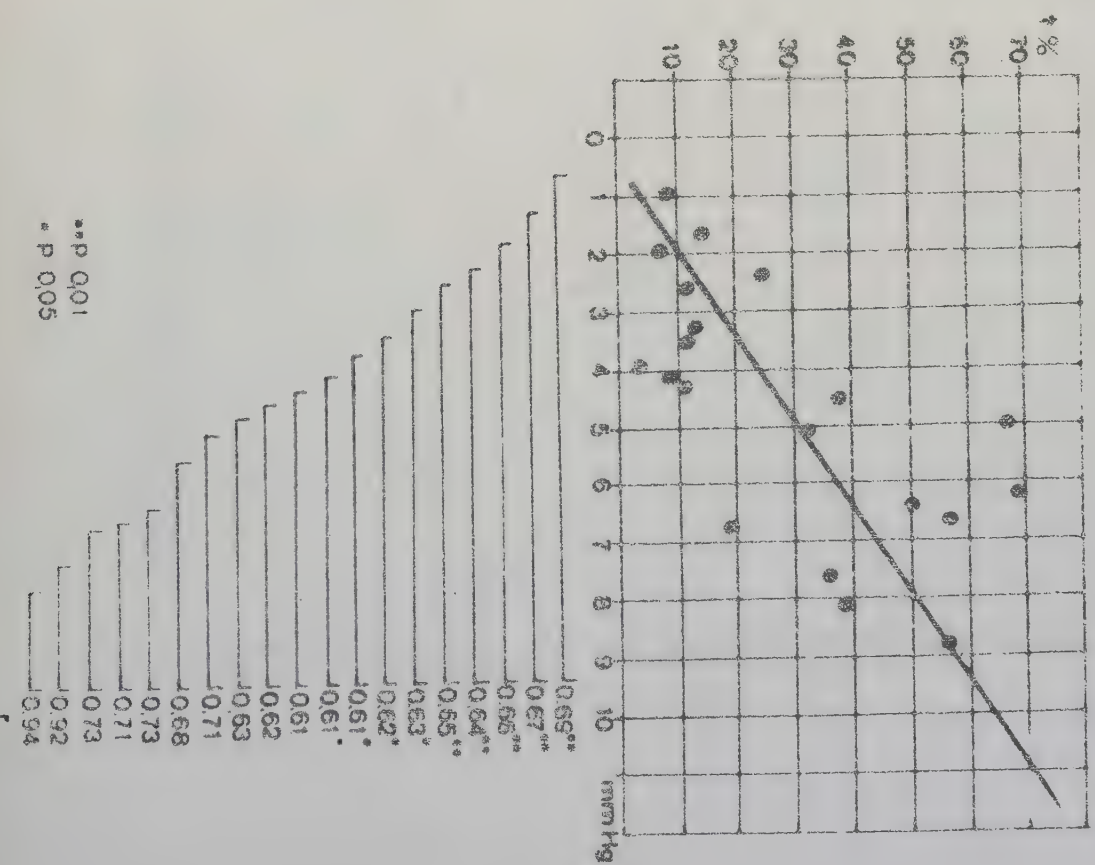
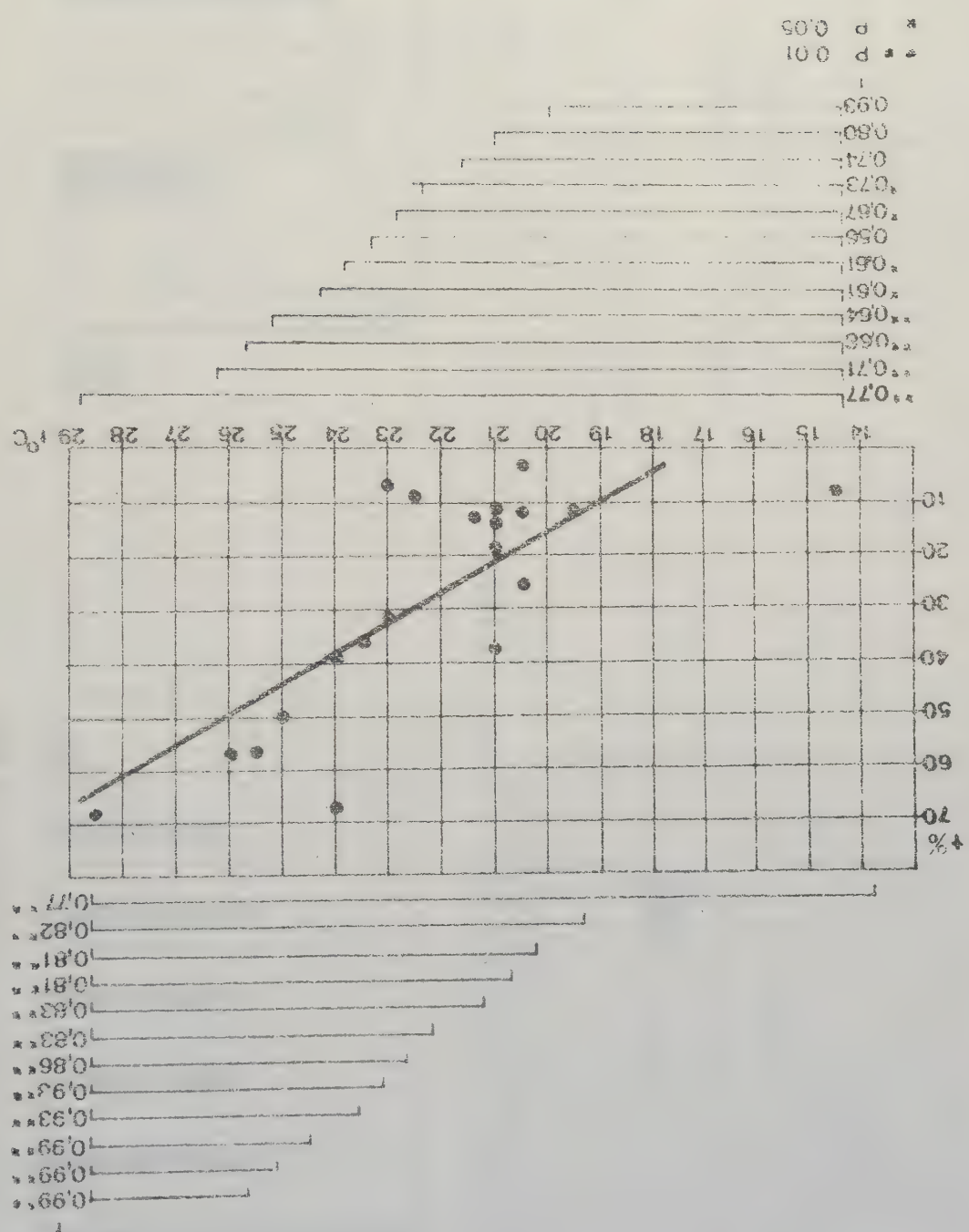


FIG.92

DEATH-RATE IN RELATION TO THE DAY MEAN VAPOR PRESSURE DEFICITE







DEATH-RATE IN RELATION TO THE DAY MAXIMUM TEMPERATURE





FIG. 94

THE WIND-DESICCATION EXPERIMENT

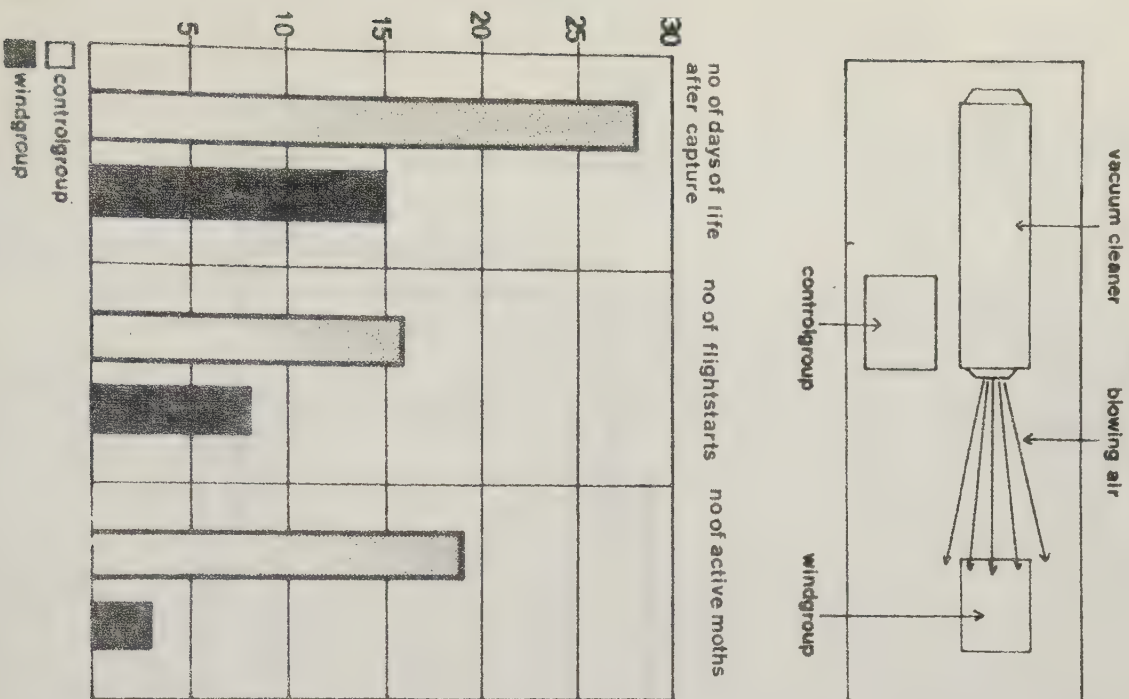


FIG. 95

DEATH-RATE OF MOTHS GIVEN FOOD AND WATER AND OF MOTHS NOT GIVEN FOOD AND WATER

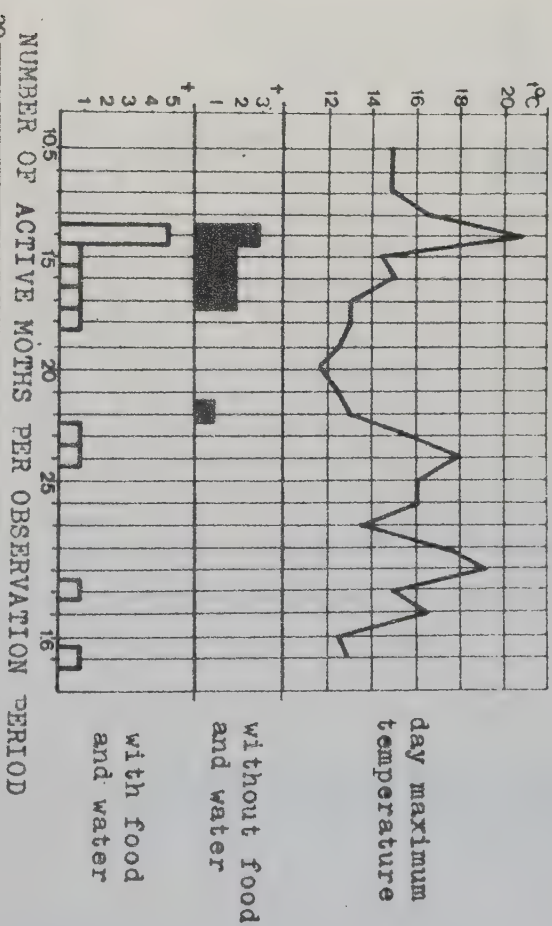


FIG. 96

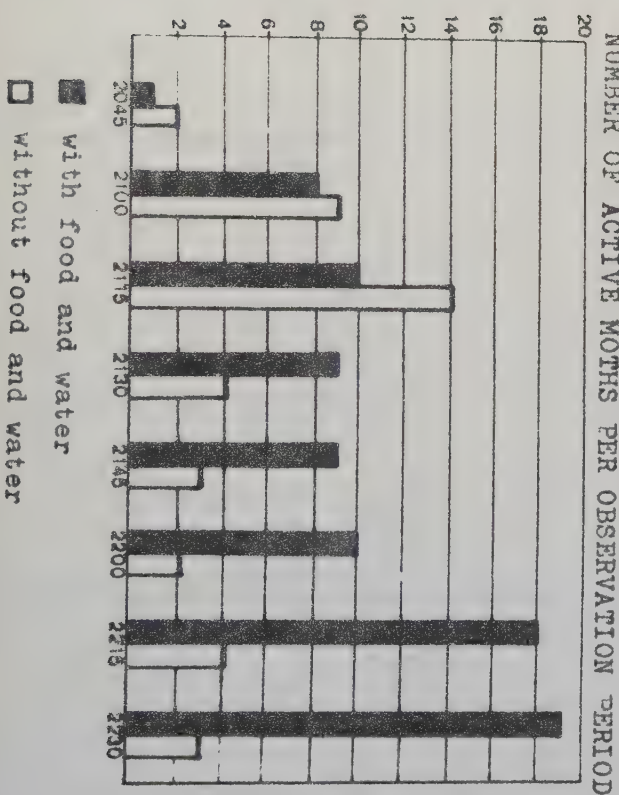
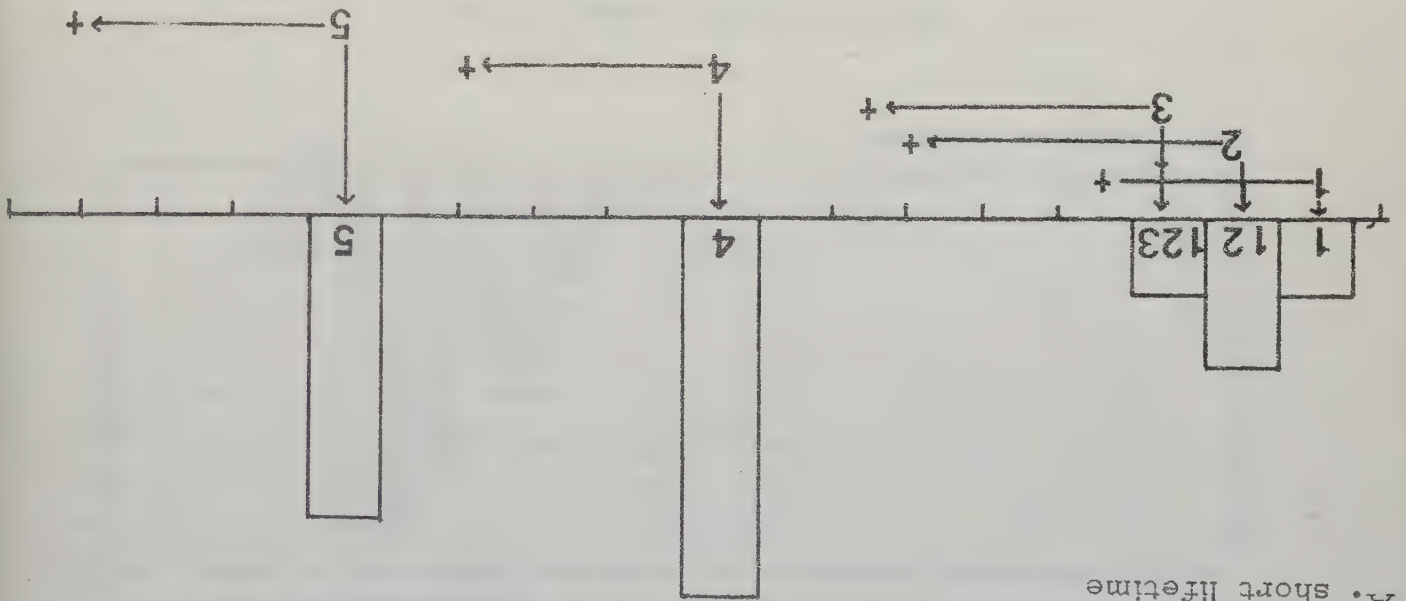


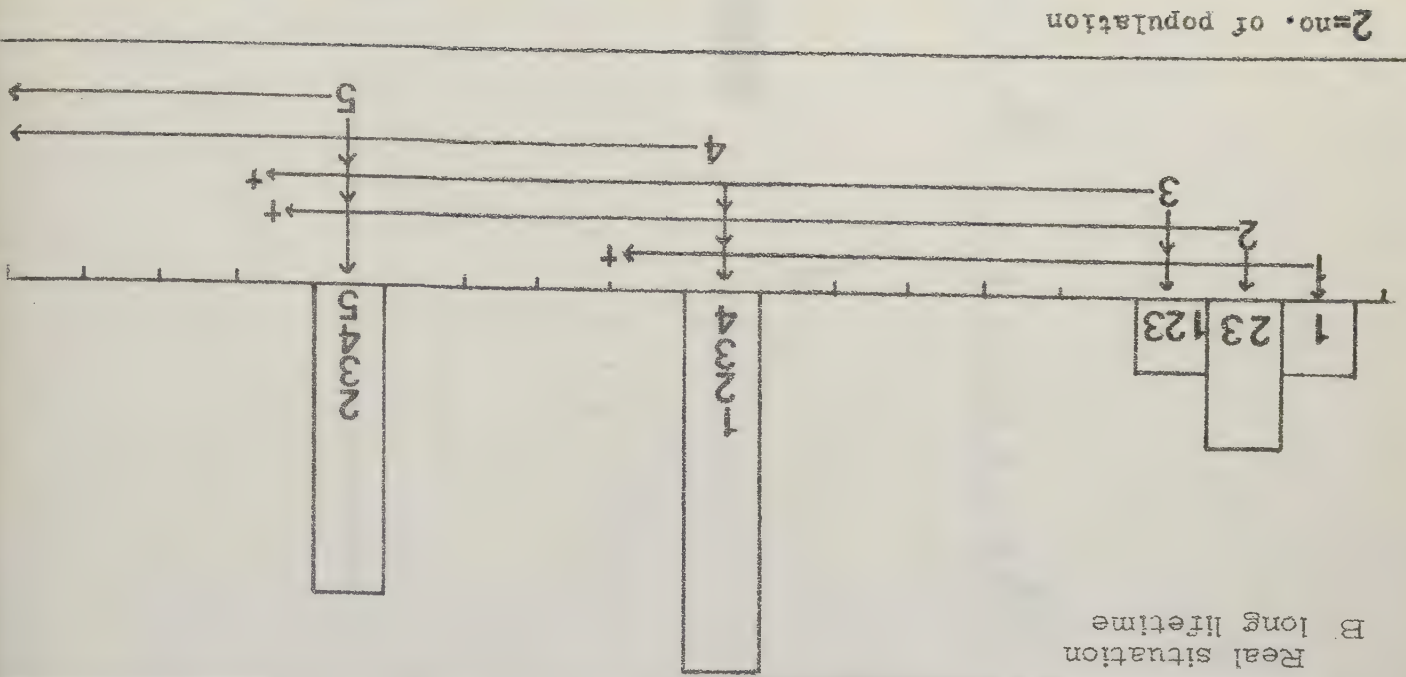


Fig. 97 THEORETICAL MODEL OF THE BENEFIT OF LONG LIFETIME ON SPRINGLIVING SPECIES

A. short lifetime



B. long lifetime



2=no. of population





FIG.98 HATCH OF ADULT MOTHS IN 1969

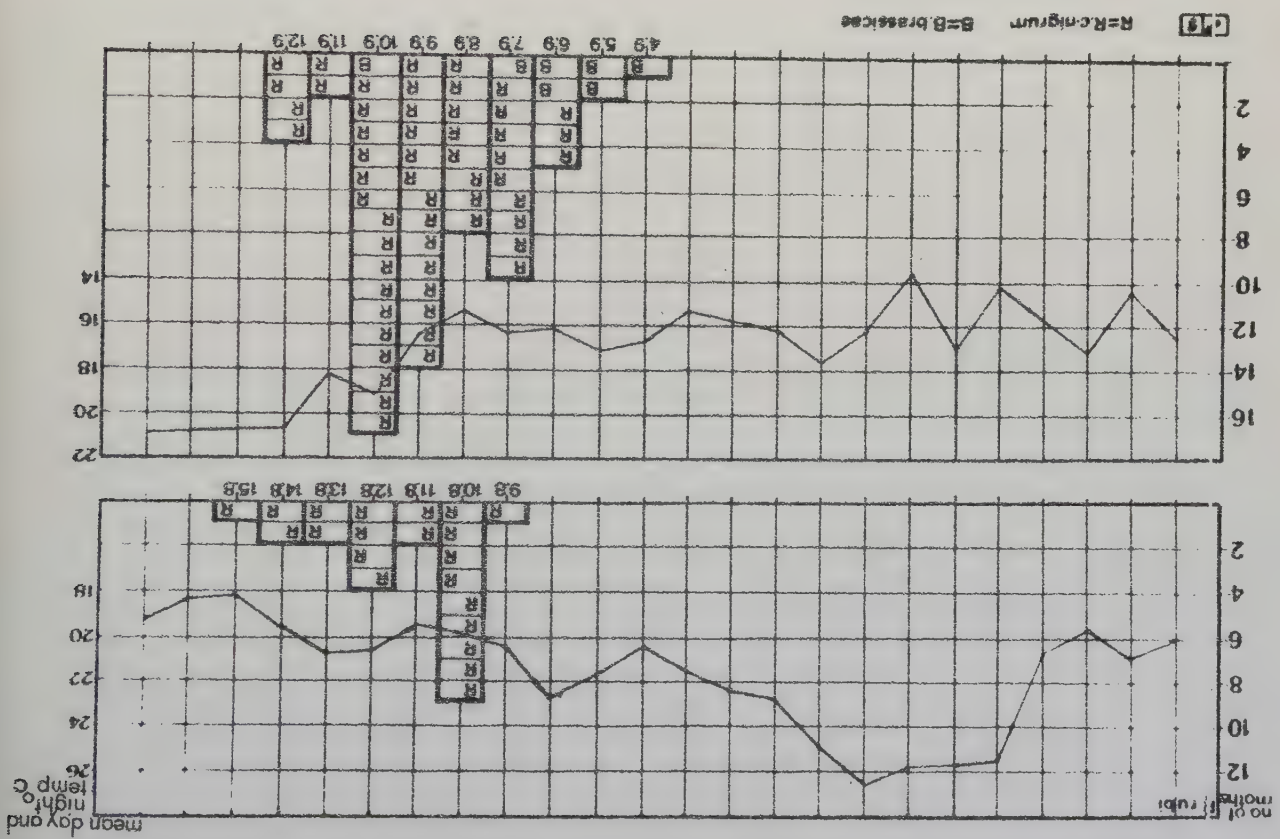


FIG.99 HATCH OF RHYACIA PLECTA IN 1970

